MANUFACTURE OF LUBRICANTS, SHOE POLISHES & LEATHER DRESSINGS

R. BRUNNER

THE MANUFACTURE OF LUBRICANTS, SHOE POLISHES, AND LEATHER DRESSINGS

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INSTRUCTIONS FOR THE PREPARATION OF ALL KINDS OF LUBRICANTS, SUCH AS AXLE AND MACHINERY GREASES, OILS FOR LUBRICATING SEWING MACHINES AND OTHER WORKING MACHINERY, MINERAL LUBRICATING OILS, CLOCKMAKERS' OILS, AS WELL AS SHOE POLISHES, LEATHER VARNISHES, DRESSINGS FOR ALL KINDS OF LEATHER AND DÉGRAS

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PREFACE

THE rapidity with which the previous editions of this work have been exhausted affords the best proof that a book dealing exhaustively with the properties and preparation of the different kinds of lubricants supplies a widespread need. Numerous letters of appreciation have reached the author, demonstrating in a satisfactory manner that his work has met the requirements of those engaged in industrial pursuits.

In preparing the present sixth edition, the author has proceeded on the same lines as in previous editions, namely, the adoption of only such recipes as have been found to answer in practice, so that those who make use of them may reliably count on obtaining products entirely suitable for the purposes in view. In addition to these useful recipes, some have been mentioned that, from their composition, do not seem calculated to give any favourable result: and in these cases appropriate critical notes have been added.

In placing the new edition before the public the author ventures to hope that makers of lubricants for their own purposes will find it reliable.

R. BRUNNER.

January 1906.

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PART I

THE MANUFACTURE OF LUBRICANTS AND GREASES

CHAPTER I

INTRODUCTORY

THE progressive extension of machinery has caused attention to be drawn to the manufacture of substances facilitating the uniform and easy running of machines. Whereas formerly the only application of substances of this nature was to cart axles and simple machines, they have now to be used on all the countless auxiliary tools that human ingenuity has devised. When it is considered that one has to deal in this connection with movements ranging from the rotation of a ten-ton flywheel on its shaft to that of the smallest wheel in a watch, or that of a dynamo shaft running at over 1000 turns a minute, it becomes

self-evident that the lubricants used for these purposes must be of a highly divergent character in order to do what is required of them, and also that the preparation of a lubricant suitable for a given purpose is a task involving a good deal of consideration. The contents of the present work clearly show what a large number of the most diversified compositions must be used in order to produce lubricants which will really be suitable for a given purpose.

The name lubricant or grease is a generic term given to the substances applied to machines and machine parts in places that are in mutual sliding or rolling contact.

In some cases the term grease is also used in connection with substances employed to soften leather, so that a distinction may be drawn between two groups of greases, namely, machine greases and leather greases.

The object of using any grease — whether intended for application to the parts of a watch, the axle of a farmer's waggon, or a russia leather shoe—is always in the endeavour to overcome, as far as possible, the resistances opposing movement, or, in the case of leather, to prevent the material getting hard.

These two purposes of greasing being so different, we will first devote our attention to the lubricants used for machinery.

The resistances opposing themselves to movement are usually termed frictional resistance. In many machines, especially those of a complex type, the frictional resistance is so great that a large expenditure of force is necessary to overcome it: the heat engendered by the friction is sufficient to make the rubbing parts red hot, an instance of this conversion of friction into heat being afforded by the well-known "heating" of ungreased axles; and it is only by the aid of suitable lubricants that this frictional resistance can be diminished to such an extent that the loss of power in overcoming friction is comparatively small.

Many machines and machine parts are run at such high speeds

that it would be impossible to keep them running safely without the use of suitable lubricants. We need only mention here the extreme velocity with which the journals of railway carriages run in their bearings. Be the two turned ever so true and fitted carefully together, the frictional resistance would soon make them both red hot. The same applies to the shafts of ventilating fans, electrical dynamos, and centrifugal separators. It is manifest that, in the absence of some lubricant, the parts in mutual sliding or rolling contact would be exposed to very considerable wear, since they would act on each other like two grindstones rubbing together.

It would thus appear that the utility of lubricants is twofold: in the first place the use of a suitable lubricant reduces the frictional resistance to such an extent that it can be overcome without any immoderate expenditure of energy; and secondly, the parts in contact are protected against unduly rapid wear. As already mentioned, it would be impossible to keep very quick-running machines in constant work without appropriate lubrication.

Before going into the subject of the various kinds of lubricants, we will first consider the question: In what does the efficacy of lubricants consist? This problem can be easily solved by a closer examination of the condition of the bodies that are in mutual sliding or rolling friction.

If we examine with a powerful magnifying glass any hard and carefully polished body, even a steel plate polished until it reflects like a mirror, it will be found full of scratches and irregularities, produced by the polishing agent on its surface. In reality, therefore, even the most finely polished body is by no means what it seems to be — namely, a perfectly smooth surface—but, on the contrary, is covered with irregularities, prominences and depressions, furrows and elongated scratches.

If we figure to ourselves two such bodies sliding or rolling

over one another without the application of any lubricant, we shall find that the prominences on the one catch in the depressions in the other, and *vice versâ*. The result is that a very considerable expenditure of power will be needed to lift the prominences on the one body out of the depressions in the other, or to draw them up as it were along an inclined plane. The frictional resistance, also, will be very great, owing to the largely increased surface resulting from the inequalities.

With this high frictional resistance is associated still another circumstance: when the speed is increased, the prominences on the one body will not always be lifted uniformly out of the depressions in the other, but many of them will be torn off, resulting on the one hand in a great expenditure of power, and on the other in a disproportionately rapid wear and tear of the machine parts in contact.

It will be easy to understand that the frictional resistance and wear will be greater in machine parts that are constructed of similar materials than in those of dissimilar materials, *e.g.* of two different metals or metal compositions, since similar bodies will exhibit similar prominences and depressions, fitting into one another and only separable with difficulty.

On this account it is the practice in many instances to make machine parts, intended to slide or roll on one another, of dissimilar materials. Thus, for example, it is usual to make shafts of cast iron or steel, whilst the bearings in which they run are of bronze or some other hard metal composition (bearing metal), these dissimilar metals wearing away less rapidly than similar ones.

With few exceptions, the lubricants introduced between machine parts in order to diminish their friction are either perfectly fluid substances or semi-solid bodies of the consistency of butter, these latter becoming fluid under the influence of the heat liberated through friction. We may therefore assume that the lubricant spreads over the surface to be greased, in the

form of a thick, oily liquid, filling up the depressions in that surface, and therefore making it far smoother than would otherwise be the case.

It is a well-known property of all liquids capable of forming drops, that their compressibility is so slight, even under the highest pressure, that for all practical purposes they may be regarded as incompressible.

If now, one machine part be sliding or rolling on another, and a lubricant is in position between them, the consequence of the presence of this fluid substance will be to prevent, either wholly or for the most part, the prominences and depressions from catching in each other. Hence the friction will be diminished, to an extent that will be greater in proportion as the machine parts in contact are harder and more smoothly polished, and the more completely the lubricant fulfils its purpose.

A few lubricants are known which consist of fine powder, and remain in that state under all conditions. They act, however, in just the same way as lubricants which are or become liquid, filling up the inequalities in the surfaces to which they are applied, and making them smooth, so that the frictional resistance is naturally lessened.

Whatever name a machine lubricant may bear, its undoubted purpose is to diminish frictional resistance, and therefore materials best calculated to accomplish this purpose must be used in the manufacture. Sometimes, however, the formulæ advanced for the preparation of so-called "improved" lubricants contain ingredients that cannot but increase frictional resistance rather than diminish it.

That the persons recommending such preparations must be unacquainted with physical and chemical laws goes without saying, anyone making a trial of such "improved" lubricants soon finding out their value.

Although at first sight it may seem easy enough to make lubricants suitable for different machines, the matter is really

a very difficult one when we come to consider all the conditions that a good lubricant is expected to fulfil.

It is only within recent times, since the use of lubricants has greatly extended, owing to the use of all kinds of machinery to an extent hitherto unanticipated, more especially in the case of railways, that the great difficulties attending the manufacture of lubricants have been properly appreciated. That complete success has not yet been attained is demonstrated by the continued appearance of new "improved" recipes, many of which are really the reverse of improvements.

When we consider the properties that a good lubricant should possess, we find the following essentials:

(1) Cheapness, in relation to the cost of the raw materials and the expense of production.

(2) Uniformity and stability of the product: that is to say, each batch of the lubricant must possess the same properties, and must not alter more than slightly, if at all, when stored for some considerable time.

(3) Absence of any corrosive action on the material of the machinery, *i.e.* the chemical properties of the lubricant must be such that it will not corrode, more than inappreciably, the metal parts with which it is brought in contact. In large machines this consideration is less important, though it is essential in the case of fine and delicately constructed machines, such as clocks, sewing machines, scientific instruments, etc.

(4) Uniform consistency at different temperatures. This property is the most important of all for a good lubricant, but is at the same time the most difficult to obtain. Most of the substances used as lubricants become thinner as the temperature rises, and conversely, thicken as it falls.

For every lubricant, however, a certain degree of fluidity, which lies between somewhat narrow limits, is necessary in order that it may discharge its functions properly. If this fluidity is insufficient, lubrication will be imperfect, but if too

great, the consumption and waste of material will be immoderate, though the lubrication be satisfactory.

The difficulties arising from this cause are so great that they cannot be entirely overcome, and in many cases a remedy is sought by using at different seasons lubricants that exhibit the proper degree of fluidity at the temperatures then prevailing. This is particularly the case with such machine parts as are exposed to all the fluctuations of temperature inherent to our climate, for example, the axles of carts and railway waggons.

Lubricants may be classified from various points of view: (1) According to the ingredients of which they are compounded; (2) according to their physical character; (3) according to the special purposes for which they are intended.

If we regard lubricants with reference to the materials of which they are composed, *i.e.* from the chemical point of view, we find that they include a very large number of substances differing considerably in physical and chemical properties. Since an accurate knowledge of these bodies and their properties is indispensable to the manufacturer, we shall go into this question fully later on.

According to their physical condition, lubricants may be classed as liquid and solid respectively. It is, however, impossible to draw a strict line of demarcation between them. Some are as fluid as a thin oil, whilst others have, at the ordinary temperature, about the same consistency as a somewhat firm butter. Between these two extremes, however, we find all the intermediate stages of consistency imaginable, so that it often seems difficult to determine whether a lubricant should be classed as liquid or solid. For this reason the system of classification on this basis is of little value.

Again, the purpose for which the lubricants are to be used may be taken as a basis of classification. Thus we may speak of ordinary cart grease, railway grease, machine oil, engine oil, and so on. But even this distinction is arbitrary, since it often

happens that a lubricant made for some special purpose can be also used for others.

On this account, therefore, it would seem preferable to classify lubricants according to the materials from which they are compounded, and then subdivide the classes in accordance with the objects for which the lubricants are intended.

Proceeding on this line, we may distinguish between the following classes:

Fatty Lubricants, namely, such as consist of either a single fat, whether liquid (oil, train oil) or solid (tallow, palm oil, etc.), or else of a mixture of several fats.

Chemical Lubricants, namely, such as consist of substances that are nowadays produced in large quantities by certain chemical processes, *e.g.* in the manufacture of coal-gas, the refining of petroleum, and various other chemico-technical processes. This class includes the so-called mineral oils, the tar oils, vaseline, the resin oils, etc. In a certain sense, too, the soaps and saponaceous bodies, occasionally used as lubricants, belong to this class.

Mineral Lubricants simply consist of certain powdered minerals that are characterised by a greasy appearance and feel (soapstone or steatite, and graphite or blacklead), and by a very low degree of hardness.

Until quite recently, the fatty lubricants were used almost exclusively, and it was only as a consequence of the development of the tar and petroleum industries that the mineral oils and greases were put on the market in large quantities. As we shall see later on, these possess, in comparison with the fats, such great advantages that they will probably displace the latter entirely. That this has not already happened is due on the one hand to the enormous consumption of lubricants, and on the other to the fact that it is not yet possible to produce chemical lubricants capable of meeting the requirements they are expected to fulfil so satisfactorily as is done by those derived from fats.

CHAPTER II

Properties of the Bodies used as Lubricants

AS already mentioned, it is specially important to the manufacturer of lubricants to know both the physical and chemical properties of the materials of which his products are compounded. In this way alone will he be able to correctly compound a lubricant, intended to fulfil any special task, with the certainty that it will prove satisfactory.

THE FATS

Fats, as is well known, are products of the animal and vegetable kingdoms, and are divided, according to their consistency, into three groups: (1) Liquid fats, which are also known as oils. (2) Semi-solid fats, of the butter or lard type, namely, such as have, at the ordinary temperature, a consistency similar to these substances. Lard and butter, in the animal kingdom, and cocoanut oil and palm oil, from the vegetable kingdom, belong to this group. (3) Solid fats, or tallows, which are solid and crumbling at low temperatures, and only become soft when heated. This class includes beef tallow, deer fat, mutton fat, etc.

Since all these fats are miscible in any proportions, it is possible, by suitably blending oils with the semi-solid or solid fats, to produce mixtures of any desired consistency and melting point.

Pure fats, to whatever group they may belong, are perfectly inodorous, quite insoluble in water, and are completely indifferent

to metals, *i.e.* have no chemical action thereon. It must be emphatically stated, however, that this applies solely to fats that are perfectly pure; and absolutely pure fats are substances that are obtainable only with difficulty, and must be stored with great care if they are not to undergo rapid alteration.

Thus, when a fat is exposed to the air, a somewhat important change is soon observed: the fat turns a darker colour, assumes a peculiar, disagreeable smell and an irritating flavour—the influence of the air soon turns it rancid. In this process, alterations of a somewhat extensive nature take place in the fat. Free acids are formed, and these are the cause of the rancid taste and smell, in addition to which they make the fats strongly corrode metals with which they are brought in contact, so that such a lubricant can hardly be used without danger, especially in fine machines.

Certain liquid vegetable fats—oils—are distinguished by a peculiar behaviour when exposed to the air, in that they darken in colour, and become progressively thicker, finally setting to a transparent, resinous mass. Oils behaving in this manner are known as drying oils. Though they are extremely important in the varnish-making industry, in painting, etc., they seem to be quite worthless for the manufacturer of lubricants, owing precisely to this tendency to gradually thicken and dry.

All solid fats become fluid when moderately warmed, furnishing liquids very similar to the ordinary oils. Since all fats, even the solid ones, must be in the fluid state before they can properly discharge their functions as lubricants, a knowledge of the melting points of the solid fats is highly important for our purpose, and we shall therefore give, later on, a short table shewing the melting and setting points of the principal fats. (The setting point refers to the temperature at which the melted fat begins to solidify again: in many fats this temperature does not coincide with the melting point, but is much lower than the latter.)

When fats are strongly cooled, the oils become thicker as the temperature falls, frequently setting completely to transparent crystalline masses. The fats that are of the consistency of butter or tallow at the ordinary temperature, become crumbling and fairly hard when cooled further.

The foregoing properties of fats indicate the manner in which various requirements exacted of lubricants can be fulfilled. For machines exposed to high temperatures, special mixtures can be prepared containing fats of high melting point, *e.g.* tallow, whilst for use at low temperatures the fluid fats will predominate in the mixture.

The varying consistency of lubricants under the influence of different temperatures makes it necessary, in the case of wheels that are exposed to considerable fluctuations of temperature, to employ lubricants of different character for summer and winter use. . . . In Central Europe the difference between the extremes of summer and winter temperature is nearly 75° F., and therefore the grease used for railway axles in summer must be of far higher melting point than that employed in the winter.

In addition to the temperature at which a lubricant is used, the velocity of the machine parts in question also influences the consistency of the preparation.

That friction is convertible into heat has already been stated; and naturally, the quantity of heat liberated from the machine parts in mutual friction within a given period of time will be greater the higher the velocity of these parts.

Hence if lubricants suitable for slow-running machines be applied to machine parts in rapid motion, the result will be that the increased liberation of heat will make the lubricants too thin. For this reason it must be laid down as a general rule that lubricants of comparatively high melting point must always be used when quick-running machine parts are in question. Thus we find, for instance, that railway companies use a

different grease for the axle boxes of express trains to that used for goods trains, the reason being that the velocity in the former case is greater than in the latter.

RESINS, VOLATILE OILS, AND CHEMICAL PRODUCTS

Although solid or liquid fats form the main ingredient in the majority of lubricants, attempts have been made, in consequence of the high price of fats at the present time, to employ in the manufacture of lubricants a number of other substances possessing suitable properties. Chief among these are the resins, volatile oils, and in recent times more particularly, a series of products obtained in the preparation of tar, crude petroleum, and ozokerite.

The application of these substances for making lubricants is the more to be commended since they can be more profitably utilised in this way than in any other. Certain by-products from large industries, otherwise only utilisable as fuel, can be very profitably employed in the form of lubricants.

Table of Melting and Setting Points of Fats and other Substances used as Lubricants

	Melting Point, °C.	Setting Point, °C.	Remarks.
Tallow (fresh) . .	42·9–43·0	33·0	
,, (old) . .	42·5–47·2	34·0	
Mutton fat (fresh) .	47·0–52·8	36·0	
,, (old) .	50·0–50·5	39·5	
Pork fat . . .	26·0–31·0	25·0–26·0	
Horse fat . .	47·5 ?	21·2 ?	
Neatsfoot oil . .	...	...	
Palm oil (fresh) .	36·0–37·0	21·0–24·0	
,, (old) . .	36·0–42·0	24·0–28·0	
Cocoanut oil . .	24·0–24·5	20·0–20·6	
Train oil . . .	...	15·0	Many sorts do not set above zero C.

Table of Melting and Setting Points of Fat and other Substances used as Lubricants—continued

	Melting Point, °C.	Setting Point, °C.	Remarks.
Rape oil . . .	...	10·0	
Olive oil . . .	...	2·0	Butter consistency at 4° C.
Ground-nut oil .	...	–7	
Grapeseed oil . .	...	–17	
Beechnut oil . .	...	–17·5	
Pumpkin-seed oil .	...	–15	Fluid at 15° C.
Stearin . . .	55·0	55·0	
Palmitin . . .	46·0–61·7	62·8	
Stearic acid . .	69·2	69·2	
Palmitic acid . .	62·0	62·0	
Mixtures of stearic and palmitic acid (½ and ½) . .	56·6	56·6	
Olein . . .	...	–10	
Oleic acid . .	...	4	Remains solid down to 14° C.
Spermaceti . .	38·0–47·0	...	
Paraffin . . .	50·0–60·0	50·0–60·0	
Naphthalene . .	79·0	...	Boils at 212 °C.
Vaseline . . .	30·0–40·0	30·0–40·0	

The Resins, which can never be used alone as lubricants, but must always be combined with solvents, are derived, as is well known, from various kinds of trees, those of the conifer family being chiefly utilised for the production of resin in Europe and America, since they can be made to yield large quantities of this substance by wounding the bark.

In Europe, preference is given to the resin derived from the pine, larch, and fir. Of late years the United States have furnished very large quantities of so-called American pine resin to the market; this product competing keenly with the European article on account of its purity and other valuable qualities, chief among them being the low price.

Next to the resins comes *Resin oil*, which is really a decomposition product of resin, obtained therefrom by distillation. Resin oil, which must not be confounded with oil of turpentine, is largely used in the manufacture of lubricants, varnishes, and printing inks.

Similar in some respects to resin oils are the products put on the market under the names of *Mineral oil*, *Naphtha oil*, *Coal oil*, *Solar oil*, etc. They are obtained as by-products in the refining of petroleum and the treatment of tar. Large quantities of these products are placed on the market from North America, the Caucasus, and latterly also from Galicia.

Vaseline is a substance obtained in refining petroleum, and forms in its pure state a white, crystalline mass with the consistency of butter. It forms an excellent lubricant for many purposes.

Naphthalene and *Paraffin* are crystalline bodies recovered from tar and also from ozokerite, and, like the resins, can only be used for lubricants in combination with liquid solvents.

Caoutchouc and *Guttapercha* consist of the dried milky sap of various tropical trees, and are met with in a purified state in commerce. They are used in a few compound lubricants, but are so dear that their employment must always be only a limited one. Moreover, it should be stated at once that numerous experiments have shewn that these expensive ingredients have not behaved anything like as well as the statements of interested manufacturers would have one believe.

The *Minerals* used in the preparation of lubricants are asphaltum, talc or soapstone, graphite, and sulphur.

Asphaltum is a dark brown to black substance, which is regarded by geologists as an impure ozokerite or resinified petroleum. It is found in various localities (the Dead Sea, Trinidad, etc.) in large quantities, and is largely used for street paving, varnishes, and lacquers, occasionally also as a component of certain lubricants. However, since it exhibits

the objectionable property of becoming brittle in winter, and soft and sticky in summer, its use as a lubricant can only be a very restricted one.

Talc or *Soapstone* (*Steatite*) is a mineral found in considerable quantities in many places, and is characterised by a very low degree of hardness (it can be scratched by any kind of wood), and a greasy lustre and feel. It is used in a powdered state for polishing marble and alabaster, and also as a grease for gloves and shoes, in addition to which it forms an excellent lubricant for wooden machinery.

Graphite or *Blacklead.*—Graphite in its purest form appears as iron-grey crystals with a metallic lustre, and in this variety, which is not of very frequent occurrence, is used almost entirely in the manufacture of blacklead pencils. The less pure lumps are used in the preparation of lubricants and for coating iron objects (stove polish). Graphite is a very soft mineral, and can be readily converted into an extremely fine powder, which has a greasy feel and forms an excellent lubricant for wooden machinery in which wood rubs against wood (*e.g.* the hoists used by well sinkers).

Sulphur.—Although this mineral is found in a pure state in nature, it is generally refined before being used for industrial purposes. It is not suitable for use as a lubricant by itself, but can only be employed in conjunction with other ingredients.

On reviewing the substances that have hitherto been used as lubricants, either alone or in association with others, the following are found to be of importance.

Animal Fats.—Tallow (beef and mutton tallow), pork fat, train oil, horse fat, neatsfoot oil, bone oil, spermaceti, sperm oil.

Vegetable Oils.—Rape oil, olive oil, palm oil, cocoanut oil, linseed oil, sesame oil, wax.

Resins and *Ethereal Oils.*—Pine resin, oil of turpentine, caoutchouc, and guttapercha.

Chemical Products.—Resin oil, coal oil, mineral oil, solar oil, oleic acid, paraffin, naphthalene, vaseline, soap, soda, litharge, sugar of lead, lime.

Minerals.—Asphaltum, graphite, talc, soapstone, sulphur.

The foregoing enumeration, from which certain substances mentioned in recipes of no practical value have been designedly omitted, shows what a large number of substances are used as lubricants, either alone or mixed together.

The properties of these bodies and of the resulting lubricants very often exhibit considerable differences, primarily due to age in the case of animal and vegetable fats, as well as to the method of preparation, etc. These differences are occasionally so considerable as to alter the properties of the resulting lubricants to such an extent that the latter turn out quite different from what is required for the purpose in view.

It is hardly necessary to say that these deviations from the desired quality are equally disagreeable to the maker and consumer of the lubricant. We therefore regard it as essential to go more fully into the properties of these raw materials, so as to enable the manufacturer to judge their quality and obtain from them every time the product he desires.

Since the deviations occurring in the properties of the fats are of special importance, these will be dealt with first.

In a perfectly fresh state, the animal fats are quite inodorous and tasteless substances, which do not react in any way with either red or blue litmus. They are neutral fats, *i.e.* they contain no trace of free fatty acid. A similar behaviour is exhibited by certain vegetable oils, such as freshly pressed olive oil, rape oil, and a large number of other oils.

When the perfectly fresh fat is packed into a cask in such a manner that the admission of air is rendered quite impossible, the fat will remain in an unaltered condition, as neutral fat, for years. If, however, the fat be exposed to the action of

the air, a peculiar chemical change, known as rancidity, soon makes its appearance.

Rancid fat is no longer neutral, but acid, which condition is revealed by its turning blue litmus red. The fat now contains a larger or smaller quantity of free fatty acids, the presence of which is betrayed by a certain peculiar smell and a sharp, irritating taste.

When brought into contact with metals like copper, iron, or bronze, perfectly neutral fat leaves them quite unaltered, whereas fat that has become acid, *i.e.* rancid, acts very energetically on metals, and greatly corrodes them. This can be very clearly seen on machine parts made of copper, bronze, or brass, the lubricant running down these parts being stained green by dissolved copper.

In large machines this action of fats on the several parts is not any great drawback, nor can it be easily prevented. The case is, however, different with lubricants intended for use in delicately constructed machinery, such as clocks, sewing machines, and others of like character.

For such machines the only permissible lubricants are such as are entirely free from any admixture of free acid, and are therefore without any corrosive action on the metal.

The vegetable oils used as lubricants should also be examined for their behaviour on exposure to the air. True, all oils will turn rancid sooner or later, but in many of them a very remarkable alteration of consistency also occurs.

Certain oils, *e.g.* rape oil and olive oil, will become very acid and somewhat thicker after a certain time, but they always remain perfectly fluid, even though kept exposed to the air for years. Other oils—which are typified by linseed oil and nut oil—have the property of becoming progressively thicker when left to stand in the air for some time, and are finally converted into solid, resinous masses.

Oils exhibiting this latter peculiarity are termed drying oils,

in contrast to the non-drying oils. The circumstance that the drying oils gradually change into solid bodies renders them unsuitable as lubricants, for when a machine that has been lubricated with such oils is left unused for some time, the oil dries on the various parts of the machine and forms a coating that is very difficult to remove. Hence the specifications for the supply of large quantities of lubricating oils often contain a clause prohibiting the use of drying oils as ingredients.

The volatile oils obtained in refining petroleum and tar are not liable to become rancid; hence, viewed from the standpoint of chemical inactivity, these oils are preferable to the fats and vegetable oils. On the other hand, many of these mineral oils thicken in course of time—though much more slowly than the vegetable oils—without, however, turning acid (rancid). They undergo conversion into resinous masses, in which event they are said to "resinify."

CHAPTER III

Raw Materials for Lubricants

In the following pages we shall give a short *exposé* of the properties of the various substances from which lubricants are compounded, accompanied by a description of the methods of purification.

I. SOLID FATS

Strictly speaking, the solid fats may be divided into two groups: the firmer kinds, or tallows, distinguished by special hardness and high melting point; and the softer, butter-like fats, or lards, comprising also certain vegetable fats, which, though solid, are nevertheless called oils. Examples of these last named are cocoanut oil and palm oil.

Tallow is the friable fat more particularly found in the carcases of ruminating animals. There are two chief commercial varieties: beef tallow and mutton tallow. The characteristic feature of tallow, its friability, decreases in proportion as other fats are mixed with it; and to the expert, this friability of tallow affords a good criterion of purity. The purification of crude tallow is now pursued on a large scale in several factories, large quantities of the raw material being also shipped of late years from South America (beef tallow) and Australia (mutton tallow). These tallow melters put the purified article on the market in the form of cylindrical blocks weighing about 1 cwt.

Tallow has about the highest melting point of any animal

fat. It is impossible to give exact figures of the melting point of the tallows, since this value alters during storage, the older the tallow the higher the melting point as a rule. Some tallows melt at 37° C. (98·5° F.), whilst others do not become fluid below 52° C. (125·5° F.).

Moreover, the melting point of tallow can be raised by an artifice. When pure tallow is melted and the resulting liquid is stirred until it sets again, a translucent mass is obtained which, when subjected to heavy pressure, exudes a certain quantity of an oily mass known as tallow oil. This oil is used either in soapmaking or in the manufacture of liquid lubricants. This artifice for raising the melting point of tallow may be advantageously employed when the preparation of solid lubricants for use in very hot localities—*e.g.* in the tropics—is in question.

Tallow is most frequently used for making lubricants that are required to remain solid at the ordinary temperature: and it is often added to compound lubricants solely with the object of raising their melting point. Manifestly, therefore, the tallow with the highest melting point will be the most useful grade for the manufacturer of lubricants.

The higher the melting point of the tallow, the smaller the quantity needed to impart the desired increased consistency to a lubricant, and on this account also, tallow freed from tallow oil is recommended.

In the form in which it comes from the butcher, tallow is unsuitable for the manufacture of lubricants, and must first be put through a special process of purification, in order to free it from the accompanying cellular tissue, blood and scraps of flesh. As already mentioned, the purification of large quantities of crude tallow forms a branch of industry, that of the tallow melter, but the operation can also be carried out easily on a smaller scale by anyone.

There are several methods of carrying out the purifying

process, the simplest being that known as "rendering." This consists in cutting up the tallow into small lumps and melting these, along with water, in a pan, over an open fire, or better still by steam. The skin and other impurities accompanying the tallow, collect on the surface of the molten mass in the form of "greaves," which are then skimmed off and the purified fat left to set hard. Though this rendering process is very simple, it furnishes only a relatively low yield of tallow, not more than 80–82 per cent., even when the greaves are thoroughly pressed.

A larger yield is obtained by melting the tallow along with dilute sulphuric acid, 1 part of this acid and 20 of water being taken to each 100 parts of tallow. Under the combined influence of the acid and warmth, all the particles of skin, etc., are dissolved in a few hours, thus purifying the tallow. The latter is obtained in a perfectly pure condition by afterwards remelting it with water. The melting must be performed in lead-lined wooden vats, by steam heat, since iron or copper vessels would be too strongly corroded by the acid.

Another very useful method of purifying tallow is with the aid of caustic soda. Three thousand parts of tallow are melted along with 2000 parts of water containing 5 parts of caustic soda in solution. Since the soda possesses the property oi combining with the free fatty acids, to form soaps, this method is particularly applicable when the tallow is very old and rancid. Moreover, the method, which in addition is the cheapest of all, has the additional advantage of entirely freeing the fat from acids.

Unless the manufacture of lubricants is being pursued on a very large scale, it is more profitable to buy the tallow from a refiner, though, for experimental purposes, it may become necessary to undertake the purifying process oneself. In this case it is best to employ the caustic soda method, since this furnishes the smallest quantity of malodorous compounds.

The lye and fat are heated together in a clean iron pot or an enamelled pan, the liquids being kept mixed by constant stirring. At the end of a few hours all the solid matters will have dissolved and the fat and lye will have formed a milky emulsion, from which the former will separate out on standing, and will float, as a clear liquid, on the surface of the lye. When perfectly cold, the purified fat can be taken off from the lye, in the form of a white, inodorous flat cake. Other fats can be purified in exactly the same manner.

Pork fat or *lard* is only obtainable in commerce at relatively high prices, and can therefore only be used to a limited extent in the manufacture of lubricants. It is also attended with the disadvantage of soon turning rancid; but, nevertheless, is well adapted for the preparation of lubricants that are desired to have a buttery consistency. It is purified in the same way as beef tallow, the rendering method being generally adopted. Old rancid tallow is purified by melting along with caustic soda solution.

Horse fat is now often met with in commerce, and can be advantageously used in making lubricants of low melting point.

Bone fat is produced in glue works and animal charcoal factories, by boiling bones and skimming off the fat collecting on the surface of the water. It is usually yellow to yellow-brown in colour, and of the consistency of butter. Being obtainable at a fairly low price, it is well adapted for making cart grease and other low grade lubricants; but when refined by treating it with soda, and filtering through animal charcoal to eliminate the dark colour and unpleasant smell, it may even be used for lubricating fine machinery, clocks, sewing machines, cycles, etc.

Neatsfoot oil, which, like bone fat, is obtained from fatty animal waste by boiling, resembles this fat in its properties, but is usually darker in colour. It is used both for making low class soaps and cart grease.

Spermaceti.—Whereas the foregoing animal fats are very often used as lubricants, spermaceti—the solid, pure-white crystalline fat obtained from the cerebral cavity of the sperm whale—has only a very restricted application for this purpose, its price being far too high to permit its more extensive employment. It melts at 38°–47° C. (100·5°–116·5° F.), and when pressed furnishes a certain amount of a fluid fat known as sperm oil.

Wax.—So far as beeswax is concerned, the foregoing remarks relating to spermaceti are applicable, this wax being far too expensive to find general employment for lubricating purposes. Nevertheless, both wax and spermaceti are mentioned in many recipes for lubricants whose valuable properties are greatly belauded. Apart from the high price of these alleged valuable lubricants, the majority have been proved useless by experience, inasmuch as spermaceti is a body that easily crystallises out from the mass, whilst wax is very brittle in the cold and sticky in the warm, thus exhibiting properties entirely opposed to those with which a lubricant should be endowed.

Palm oil.—This fat, which is now largely met with in commerce, is obtained by boiling the fruit of several varieties of palm, more especially the Guinea oil palm (*Elaiea guienensis*). When fresh it has the consistency of butter, a bright yellow to orange colour, and an agreeable smell; but old palm oil is firmer, friable, darker in colour, and of unpleasant smell.

In the manufacture of lubricants it is highly important to know whether a given sample of palm oil is fresh or stale, since there is a great difference in the melting points of the two, fresh palm oil melting at 27° C. (80·5° F.), whilst old oil does not melt below 42° C. (107·5° F.).

For the majority of lubricants, palm oil can be used as it is, and in this event it imparts its characteristic yellow colour to the mass. If, however, the colour is undesirable, the oil must be bleached.

This operation can be carried out in a simple manner by melting the oil as quickly as possible, then heating it to 240° C. (46° F.) and maintaining it at this temperature for a quarter of an hour. It may also be bleached by treating 1000 parts of the melted fat with 1–1½ parts of bichromate of potash and an equal quantity of sulphuric acid. The entire mass turns green at first, a green liquid afterwards settling down, leaving the bleached palm oil floating on the surface.

Cocoanut oil is obtained in the same manner as palm oil, but from the fruit of the cocoanut palm (*Cocos nucifera*). It is white or greenish in colour, and has a peculiar, unpleasant smell. Commercial cocoanut oil is generally utilised for lubricating purposes without any special purification; but when the removal of the disagreeable smell is desired it must be heated strongly for some time. Both palm oil and cocoanut oil are generally very acid, and are therefore unsuitable in their crude state for lubricating fine machinery.

II. LIQUID FATS

The liquid fats are such as are fluid at the ordinary temperature, though the majority of them set when the temperature is slightly lowered. In many cases the solidification is only partial when the temperature is not very low, but when greater cold is applied, all the liquid fats become solid.

As lubricants, the liquid fats are very important for machines that are desired to run evenly or that contain fine parts. Whilst the fats solid at the ordinary temperature are best adapted for greasing waggons, the liquid fats are admirably suited for the preparation of machine oils.

Liquid fats of animal origin are usually known as *train oils*, whilst those belonging to the vegetable kingdom are called simply *oils*.

Train oil.—Under the names train oil, fish oil, seal oil,

etc., a number of oily liquids appear in commerce, ranging in colour through all shades from pale yellow to black, and distinguished by a peculiar, unpleasant smell. In general they are derived from the blubber of certain marine animals, the great bulk being obtained by melting the fat of various kinds of seals and whales. One kind of train oil, codliver oil, is obtained from the liver of the codfish.

The train oil brought in enormous quantities every year into European and American ports by whalers, is about the cheapest of all fats. Apart from its use in soapmaking and the production of shamoy leather, it is also employed as an excellent lubricant, its chief advantages for this purpose being its oily character and low price.

The cheapest dark and evil-smelling train oil can be used in the preparation of common lubricants, but for finer products it is essential to use the refined oil, which is of a golden yellow colour and has a less penetrating smell.

Sperm oil.—Among the liquid animal fats which still find employment, even though to only a limited extent, as lubricants, mention must here be made of the aforesaid sperm oil. It is obtained, in small quantities, by pressing spermaceti, is almost colourless, and fairly thick, but is far too high in price to be more largely used for the purpose now in question.

Though, apart from such as dry very quickly, all the numerous oils of vegetable origin *can* be used as lubricants, as a matter of fact only a very limited number are actually so used.

Rape oils.—Various kinds of oil, differing considerably in their origin, though closely allied in properties, are met with in commerce under the name of rape oil. The chief commercial varieties are Rubsen or colza oil, and rape oil. They are obtained, by cold or hot pressing, from the seeds of various plants of the Brassica family. Like all other vegetable oils, they cannot be used immediately on issuing from the press,

but must first be refined. Since this point will be dealt with more fully later on, there is no need to do more than mention it at present.

Olive oil.—As is well known, the olive tree (*Olea Europæa*) furnishes an elongated round fruit of a peculiar green colour, the olive. This contains a hard stone, surrounded by a pulp which is very rich in oil. Such portions of this oil as are recovered by moderate pressure at the ordinary temperature, are pale yellow and inodorous. The finest kinds of olive oil are used exclusively for edible purposes, only small quantities finding employment in the preparation of lubricants for fine machinery.

When the residue left from the cold-pressing of olives is pressed again in the warm, a yellowish green oil of unpleasant smell is obtained; and this is used as a lamp oil, as a raw material in soapmaking, and also in the manufacture of lubricants.

On leaving the residue from the warm pressing to stand, it begins to ferment, the cellular tissue of the fruit pulp is completely decomposed, and the remainder of the contained oil is liberated. On pressing this mass a considerable additional quantity of oil is recovered, which is known as factory oil, *huile d'enfer*, *huile tournante*.

This oil, as a rule, is strongly acid, very dark coloured and evil smelling, and can only be used for the preparation of low class soaps, lubricants for coarse machinery, and for certain purposes in the textile industry.

Of the other non-drying oils finding practical employment as raw materials in the manufacture of lubricants, only the most important will be mentioned here.

Beechnut oil.—The fruit (mast) of the common forest beech yields, when pressed, up to one-fifth of its own weight of oil, the cold-pressed grades being of such excellent quality as to be fit for use as edible oil. Hot-pressed beechnut oil is

darker in colour and has a peculiar smell, but can very well be used as a lamp oil or lubricating oil.

Beechnut oil is very fluid, a property distinguishing it clearly from other fatty oils. On this account, and also because of its valuable property of setting only at a very low temperature, it forms an excellent lubricant for fine machinery that is set up in cold places.

Although the raw material for beechnut oil is available in large quantities, this valuable oil is nevertheless only prepared in comparatively small amount.

Pumpkin oil, from the seeds of the pumpkin or gourd, is of a dark green colour and furnishes very good lubricants, which, however, entail a frequent cleaning up of the machinery on which they are employed, because the oil belongs to the drying, or rather semi-drying category.

Of the fatty vegetable oils still used in any noteworthy quantity as lubricants, mention should be made of sesame and ground-nut oil.

Sesame oil.—The seeds of the sesame plant (*Sesamum orientale*) are extremely rich in a fatty oil, which when cold pressed is used as an edible oil, whilst the warm-pressed oil serves as a lamp oil and lubricant.

Ground-nut or *Arachis oil* is obtained from the seeds of the ground-nut (*Arachis hypogæa*), which is grown in Southern Europe. It is used as an edible oil, lamp oil, and for lubricating machinery.

Cottonseed oil or *Cotton oil* is obtained in large quantities from the seeds of the cotton plant, and is extensively used in soap-making. It is a pale yellow, non-drying oil, and is well adapted to replace rape oil or olive oil as a constituent of lubricants.

Linseed oil.—This oil is produced in large quantities from flax seed (linseed), and on account of its great drying properties is a valuable raw material for varnish-making. It is also used as a lubricant, though unfit for that purpose.

Pure linseed oil is not very thick, has a fine golden yellow colour, characteristic smell, and, when spread out in thin layers, exposed to the air, slowly dries to an elastic, resinous mass. Boiled along with litharge or certain other substances, it is converted into varnish ("boiled oil"), and then dries very quickly in the air.

Oleic Acid.—Closely allied to animal and vegetable fats is the chemical product oleic acid, which can be recovered from both classes. It is obtained by pressing the cakes of fatty acid produced, in the stearine candle process, by saponifying fats with lime and decomposing the resulting lime soap with sulphuric acid. Under the heavy pressure exerted in the hydraulic press, the liquid oleic acid is forced out from the crystalline stearic and palmitic acid.

The oleic acid thus obtained forms an oily, yellow to brownish liquid, which from its physical properties would make a very good lubricant, were it not that the chemical properties render it entirely unsuitable. As the name implies, it is a *free acid*, and as such corrodes metals, the action being so energetic that this substance is actually used for cleaning copper, brass, and bronze articles. When used as a lubricant it naturally acts on the metal parts with which it is brought into contact, and greatly corrodes them.

III. RESINS AND ETHEREAL OILS

When the bark of coniferous trees is wounded, it exudes peculiar, strongly odorous and semi-solid bodies, to which the name "turpentines" or "balsams" is given. On these turpentines being heated, a portion of the mass volatilises, and condenses to oily, strongly odorous liquids, termed "ethereal oils," the non-volatile residue being known as "resin" or "pitch."

The so-called ethereal oils differ from the true or fatty oils, more particularly inasmuch as, when heated, they volatilise completely, without residue, whereas this is not the case with

the fatty oils. The ethereal oil most largely met with in commerce, and also the most important for our purpose, is—

Oil of Turpentine, which is mainly obtained from the turpentine exuded by fir trees. Pure oil of turpentine is a thin, highly inflammable substance, with a high index of refraction, penetrating smell, and water-white or faintly yellowish appearance. It is also distinguished by the property of partially or wholly dissolving resin or resinous bodies such as caoutchouc and asphaltum. As we shall see later on, these solutions are used in the preparation of certain peculiar lubricants.

Pine Resin is, as already mentioned, obtained by distilling crude turpentine, being left behind in the still, as a residue, after the oil of turpentine has distilled over. In general it forms brittle masses, which soften when heated, vary in colour from honey or amber yellow to reddish, dark brown, or black, according to the degree of purity, and are known respectively as colophony, red resin, and "black rosin," or pitch. Latterly, great quantities of pine resin, almost colourless to red-brown, have come into the market from the United States. On heating melted pine resin to decomposition point (dry distillation), it furnishes resin oil, which we shall deal with in the section on chemical products.

Asphaltum forms black masses, more or less brittle, and with a peculiar smell. It is either mined or else obtained in volcanic localities, such as the Dead Sea, the Pitch Lake of Trinidad, and other places. Asphaltum stands in the same relation to petroleum as pine resin does to oil of turpentine, and it is generally regarded as being nothing but more or less completely resinified petroleum, contaminated with dark-coloured substances. It is readily soluble in oil of turpentine, petroleum, and other ethereal oils, and is very extensively used in the chemical industry, especially of late years. On the other hand, it has only a limited application in making lubricants.

Caoutchouc.—This substance, which is well known on account

of its elasticity and its power of erasing lead-pencil marks, is distinguished by its solubility in certain volatile substances, *e.g.* the light tar oils. As already mentioned, there are only a few lubricants of which it forms an ingredient. This applies also to the allied substance, guttapercha.

IV. CHEMICAL PRODUCTS

Since the great extension that has taken place in that branch of chemical industry known as the tar industry, a large number of products formerly wasted have found useful applications. The number of these substances has been considerably increased by the by-products obtained in refining petroleum.

The products recovered from coal tar and lignite tar include certain substances greatly resembling the ethereal oils in their properties generally, though differing therefrom for the most part by possessing higher boiling points and greater viscosity. These are distinguishing features of the heavy tar oils in particular.

Mineral oil, Naphtha oil, Coal oil, Solar oil are oily liquids of this kind, obtained in the distillation of tar, crude petroleum, ozokerite, etc. The insignificant differences between these oils are chiefly to be sought in their divergent densities; and on this basis the oils are divided into light and heavy mineral oils.

When lignite tar is distilled, the first runnings consist of the most readily volatile ethereal oils, which find employment as solvents. These are followed by oils of somewhat higher boiling point, serving more particularly for illuminating purposes. At still higher temperatures, thicker and heavier oils come over, and these chiefly find employment as lubricants. These are the oils that are now put on the market—more especially from the United States—under the names, mineral lubricating oil, vulcan oil, etc., and are coming more into use both on account of their excellent lubricating properties and

of their valuable characteristic of having no corrosive action on certain metals. On continuing the distillation of the tar after these oils have passed over, they are followed by compounds which form crystalline masses on cooling. These are—

Paraffin and *Naphthalene*, two substances that are readily soluble in certain liquids, with which they form butter-like or fatty masses, very suitable for lubrication. In some refineries treating lignite tar, the distillation is not pushed so far as to drive off all the oils of high boiling-point, but is only continued to such a degree as to leave in the still a residue possessing just the properties enabling it to be used as axle grease.

Resin ("*Rosin*") *oil.*—This product is mostly recovered from cheap American pine resin ("rosin") by dry distillation. Various distillates are formed, one portion consisting of pure oil of turpentine, which already existed in the resin, whilst the other portion is composed of products formed during the decomposition of the resin. According to the age of the resin and the distillation temperature, the properties of the resin oil vary, the colour ranging from yellow to brown, and the fluidity differing. The resin oils are readily miscible with fats and resins, and have latterly been extensively used as lubricants, either by themselves or in association with other ingredients.

Other chemical products used in making lubricants include, as the most important, soap, soda, and lead compounds.

Soap is prepared, as is well known, by decomposing fat with caustic soda or potash lye. The soda soaps remain very firm, even though they contain a high percentage of water, whereas the potash soaps are soft and smeary, even when the proportion of water is small,—hence their name of "soft soap." The lime soaps are invariably solid, and insoluble in water; and the same applies also to the soaps of all other metallic oxides except the lead soaps, which at the ordinary temperature form soft and very sticky masses (lead plaster). Soaps are used as

lubricants, both alone and as an addition to others. Soap dissolved in water is also used for lubricating.

Soda, which is a very important ingredient of many largely-used lubricants, is a salt which takes the form of large colourless crystals, that have an alkaline flavour and are distinguished by the property of efflorescing on exposure to air, that is to say, they part with their water of crystallisation and fall to a white powder.

These properties are those of pure soda, *i.e.* the preparation containing at least 90 per cent. of pure soda, sodium carbonate. Under the name of soda, however, a number of mixtures of sodium carbonate and sodium sulphate (soda and Glauber salt) are found in commerce that very often contain only 30 per cent. of soda, and must be regarded as intentionally adulterated.

When a solution of soda is shaken up with a fat, the entire mass is converted into a milky liquid. Soda, like potash (potassium carbonate), caustic potash, and caustic soda, has the property of bringing the fat into a state of very fine division, so fine indeed, that the fat takes the form of very minute drops. These mixtures are known as emulsions, and are not infrequently used as lubricants.

Litharge.—This preparation appears in commerce in two forms, pale and dark. It is a heavy powder, and is formed by strongly heating molten lead in air. Boiled along with fats it furnishes soap-like compounds, the so-called lead soaps or lead plaster, characterised by high adhesive properties. The diachylon plaster of the apothecary is merely a lead soap.

Sugar of Lead (*Lead acetate*) is met with in commerce as heavy, colourless crystals, which readily effloresce in the air, and are very soluble in water. The solution has a sweetish taste, hence the name sugar of lead. Chemically speaking, this substance is lead acetate.

In addition to the foregoing substances, various others are used in the compounding of certain lubricants. As, however,

they are seldom employed, they need not be mentioned until we come to deal with the properties of the lubricants themselves.

V. MINERALS

It has been already stated that a certain group of minerals, the talcs or steatites, have a greasy feel, and such a low degree of hardness that they are easily scratched by a piece of wood or the finger nail.

Talc or really *Steatite* (*stear* being the Greek word for tallow), so called on account of its particularly greasy feel, is often found native, mostly in the form of bluish-green masses, and is converted into a lubricant for wooden machines by simply reducing it to powder. The word talc is derived from the Swedish "taelga," which means "to cut," the mineral being very easily cut with a knife.

Soapstone, which also belongs to the steatites, is a white mineral of fatty appearance, and so soft that it can be cut into thin pieces, which will mark slate or cloth, so that the mineral is used for writing on slate, and as the so-called French chalk employed by tailors. In the state of powder it is also used for dusting the insides of new boots and gloves, to make them smooth.

Sulphur.—This well-known combustible mineral, with its peculiar yellow colour, is met with in commerce in various forms, namely, as flattish round sticks, rod sulphur; in the form of powder, powdered sulphur; and finally in the state of fine meal, flowers of sulphur. Though the latter form is in the finest state of division, it should never be used for lubricating purposes, since it always contains a certain amount of sulphuric acid or sulphurous acid, which will corrode the surface of the metal lubricated, and freshly powdered rod sulphur must therefore be used in all cases.

Graphite or *Blacklead*, the well-known mineral that will

mark almost anything, and in the form of lead pencils is used for writing, is also very suitable for lubricating purposes, being quite inert towards metals.

As already mentioned in the introduction, lubricants may be classified, either according to their physical condition—as solid, semi-solid, and liquid—or else in accordance with their uses (lubricants for axles, steam engines, bearings, etc.). Another form of classification is practicable, namely, according to the chemical substances used as ingredients, in which case we may distinguish between fatty, chemical, and mineral lubricants.

For practical purposes, however, it seems advisable to depart from these divisions to some extent, by combining them instead of taking them seriatim. By adopting this plan, the reader will be placed in a position to have all the solid or liquid lubricants under consideration together, thus facilitating comparison.

Similarly, the lubricants used for clocks, sewing machines, etc., are grouped together in a separate section, so that they can be compared, or new combinations elaborated.

The present book being mainly designed for the practical use of those who make lubricants or desire to do so, the author believes that the deviation he has permitted himself from the strictly logical system of classification, is the more justifiable since the properties of the raw materials used in the preparation of the various lubricants have already been fully described.

CHAPTER IV

Solid Lubricants

AS the chief ingredients of solid lubricants, two fats come into special prominence: animal tallow and palm oil. The latter, which is distinguished by its low price, is very largely used now for the preparation of machine greases.

To these fats, certain liquid animal and vegetable fats (train oil, rape oil, etc.) are added, to make the lubricants somewhat softer; a certain amount of soda is added, to partly convert the fats into emulsions, or they are partly saponified by the aid of soda lye. Finally, it is also possible, by the addition of inactive solid substances (which, of course, must be very finely ground), to thicken the lubricants for certain purposes, powdered soapstone, talc, and sulphur being employed in such cases.

By the suitable use of such adjuncts, any lubricant can be made to acquire the properties desired for a given purpose; and it is always advisable to prepare a stock composition which can then be easily modified in a suitable manner. In the present instance this stock composition consists of a mixture of fats, which may, if desired, be boiled with water and soda to form an emulsion.

The foregoing substances do not exhaust the list of bodies used for making solid lubricants; for certain purposes, use is also made of other admixtures, such as paraffin, naphthalene, graphite, and also colouring matters, in order to impart a special colour to the product: or very peculiar combinations are prepared from caoutchouc, guttapercha, asphaltum, and other substances, though this class of lubricant has only a very restricted use.

CHAPTER V

Tallow Lubricants

TALLOW grease is always a serviceable article, but it is somewhat dearer than other lubricants. Tallow changes in consistency very considerably according to the temperature. In the height of summer it is on a par with soft butter, but perfectly hard and friable in very cold weather. Owing to this behaviour, various railway companies, the Austrian State Railway for example, where this class of grease was used for the waggons and locomotives, used a grease of different composition each month. The relative proportions of these mixtures are given in the following table:

For the Month of—	The Grease consists of—		
	Tallow.	Olive Oil.	Pork or Horse Fat.
January . . .	100	20	18
February . . .	100	18	16
March . . .	100	14	12
April . . .	100	9	7
May	100	4	2
June . . .	100	$1\frac{1}{2}$	1
July	100	1	$\frac{1}{2}$
August . . .	100	1	$1\frac{1}{2}$
September . .	100	$1\frac{1}{2}$	2
October . . .	100	4	3
November . .	100	8	7
December . . .	100	14	12

More recently, the opinion has prevailed that there is no practical advantage gained from using so many different grades, and at present the railway mentioned uses only three kinds of lubricant, namely, one for the winter, another for the summer, and a third for spring and autumn. These are compounded as follows:

Grease for—	Tallow.	Olive Oil.	Old Grease, Pork, or Horse Fat.
Winter use . .	100	20	13
Spring and Autumn .	100	10	10
Summer . . .	100	1	10

(The old grease is the residue left in the grease boxes from one filling to the next, and usually has the consistency of pork fat.)

These greases are prepared by melting the fats together and heating them to about 302° F., the mixture being kept stirred until this temperature is reached, whereupon the mass is left to set.

In working on the small scale, a simple tub is sufficient for this operation; but for larger quantities it is advisable to melt the fats in a pan fitted with stirrers. The liquid and more easily melted fats are placed in the pan first, the tallow being added last.

TALLOW AND TRAIN OIL GREASE

Refined tallow	2 parts
Train oil	1 part

The tallow is melted, at a moderate temperature, in a pan, and as soon as this has been done the train oil is added, the mass being crutched until a perfectly uniform mixture has been produced.

In making axle grease for cold countries, the proportion of train oil must be increased to give the grease the necessary fluidity. The larger the quantity of train oil, the softer, more buttery, and more easily melted the mixture will be.

In the case of all lubricants it is necessary to remember that a given recipe is suitable for a certain climate only, and must be correspondingly modified to suit warmer or colder districts.

SULPHUR AXLE GREASE

Refined tallow	2
Train oil	2
Powdered sulphur	1

The tallow is melted, heated to about the boiling point of water, and the train oil is added. The fats are mixed by vigorous crutching, and the powdered sulphur is thrown in. The whole is then kept for another ten minutes at the above temperature, after which the fire is drawn and the mixture is stirred until it has set to a perfectly homogeneous buttery mass.

It is important that the sulphur should not be added in any other form than that of a very fine, floury powder, since larger fragments of sulphur would not give a uniform product.

BOOTH'S PATENT GREASE

	I.	II.
Refined tallow	6	8
Palm oil	12	20
Water	8	10
Soda	1	$1\frac{1}{2}$

For both recipes the tallow is melted first and heated to about 265° F., the palm oil being stirred in. The soda is dissolved in water in a separate vessel, either at ordinary temperature or by the aid of warmth, and the solution is run,

in the form of a thin stream, into the mixture of tallow and palm oil, which is kept constantly stirred the while. After the whole of the soda has been added, the fire is drawn, and the mass is stirred until it begins to set and to offer considerable resistance to the stirrers.

The axle greases prepared according to these recipes are of excellent quality, and are still exclusively used on most English railways. The consistency can be altered at will by varying the proportions of tallow and palm oil; if the former be increased, the grease is firmer and harder to melt, whilst an increase in the amount of the palm oil makes the product melt at a lower temperature and imparts a more buttery consistency.

TALLOW AND NEATSFOOT OIL GREASE

Tallow	100
Neatsfoot oil	100

This grease was used for a long time on the Württemberg railways: it is very thick, and therefore specially suitable for summer use, but is rather dear.

TALLOW, RAPE OIL AND SODA GREASES

1. *Winter Grease*

Tallow	180
Refined rape oil	120
Soda	20
Water	360

2. *Spring and Autumn Grease*

Tallow	230
Refined rape oil	85
Soda	20
Water	350

3. *Summer Grease*

Tallow	260
Refined rape oil	55
Soda	20
Water	340

French Tallow and Train Oil Grease

Tallow	260
Train oil	230
Soda	23
Water	500

Tallow and Castor Oil Grease

Castor oil	140
Pork fat	14
Tallow	7

This lubricant, though very useful, can only find restricted application for fine machinery, owing to the high price of the castor oil.

CHAPTER VI

Palm Oil Greases

A VERY large number of recipes for solid lubricants contain palm oil, and the products are very widely used for greasing axles, railway wheels, flywheel shafts, and other quick-running machine parts.

Palm oil lubricants have generally a fine yellow colour, ranging as high as orange, and due to the use of unbleached palm oil, which, as already stated, is yellow to orange-red in colour.

Some greases are made of palm oil alone, unmixed with any other fat. Experience, however, has shewn that these, though low priced, do not possess the properties expected of them. As a rule their melting point is too low, so that under the influence of the warmth generated by the movement of the machine parts they become too thin, thus entailing a considerable waste of grease in the case of locomotive machines. Hence the purely palm oil greases are not very suitable for cart and railway axles, since they drip off the axles too readily, and waste to an extent that would render the expense of lubrication gigantic in the case of railways, etc.

Generally the palm oil receives an addition of tallow to raise the melting point of the mixture. Conversely, in the rare instances where stress is laid on a low melting point, liquid fats, such as train oil or rape oil, are added.

These additions increase the cost of the palm oil greases

considerably; but when the quality comes to be taken into consideration, the improvement is so great that the cost appears of little importance.

When the greasing of locomotive machinery is in question, such as cart and railway axles, where the recovery of the runnings is not so easily possible as with stationary machines or marine engines, good results are obtained with compound palm oil greases. These are expensive to produce; but, in reality, they are cheaper than unmixed palm oil, since a given quantity of the grease will last longer.

The mixed palm oil greases vary in composition to such an extent that the proportion of additional fats may range between 35 and 50 per cent.

PALM OIL AND SODA GREASE

Every palm oil grease, to be serviceable, must contain a small addition of soda (crystallised sodium carbonate), since this ingredient determines the usefulness of the product.

As already mentioned, soda, like the other alkali carbonates and hydroxides (caustic alkalis), has the property of converting fats into emulsions. When soda solution is shaken up with any liquid or artificially liquefied fat, the liquid gradually assumes a milky appearance. Under the microscope it is colourless, but is found to contain innumerable fine drops of fat, distributed in the same way as butter is in milk (which is also colourless in reality).

The formation of these emulsions serves a double purpose: primarily to enable a large quantity of water to be introduced into the lubricant, namely, the water in which the soda is dissolved. This greatly increases the bulk of the lubricant, without adding to its cost.

The second purpose served by the use of soda appears to be as follows: Palm oil consists largely of palmitin (a compound of palmitic acid and glycerine), but also invariably

contains appreciable quantities of free fatty acids, this being especially the case in old samples of the oil.

As already mentioned in treating of oleic acid, the free fatty acids have the property of strongly corroding metals, and for this reason pure palm oil greases have a very destructive effect on metals. However, when a sufficient quantity of soda is present in the grease, the fat is emulsified on the one hand, enveloped by the soda solution, and therefore its action on the metal is diminished; and on the other hand, certain fatty acids have the property of displacing the carbonic acid from soda, and combining with the base to form the compounds known as soaps.

The property of saponifying free fatty acids, and even of extracting the fatty acids from fats, and combining with the former to form soaps, at the ordinary temperature, is possessed by the caustic alkalis. So that if the soda be replaced by caustic soda, the whole of the fatty acids present in the free state will be at once saponified, during the preparation of the lubricant, and there will therefore be no danger of the machine parts being corroded in any way.

To convert a lubricant in which soda is used as a preparatory ingredient, into one containing caustic soda, the following simple operation may be performed:

The quantity of soda to be used is dissolved in a tenfold amount of water, and is boiled in an iron pan for several minutes with a quantity of slaked lime equal to that of the soda taken, the latter being thereby converted into caustic soda. The liquid is left to stand in the closed pan, and drawn off after the lime has settled down.

Caustic soda can also be obtained in the solid form, and when the price is low it can be used direct in the preparation of greases, the quantity required being about three-fourths the weight of soda generally used. The method of procedure is just the same as with soda solution, and takes less time, the

caustic alkali combining with the fats more easily and quickly than the carbonate.

THE PREPARATION OF PALM OIL AND SODA GREASES

The simple operation of preparing these greases is modified according as the quantity to be dealt with is large or small. For small quantities up to 2 cwt., the work may be done in an ordinary pan, mounted in brickwork and heated by direct fire. For larger quantities, it is advisable to employ steam as the heating agent, and to effect the stirring with mechanical appliances, instead of by hand.

Experience has shewn that the quality of these greases is always better when they are prepared on the large scale. This can be accounted for by the circumstance that the larger mass of material retains its fluidity longer, so that a more intimate admixture is possible.

Operations are begun by placing the fat with the highest melting point (usually the tallow) in the pan first, and adding the palm oil when the first charge is melted, the two being then mixed completely by stirring, and raised to the temperature of boiling water.

The soda or caustic soda is dissolved in the prescribed quantity of water in a separate pan, heated to boiling, and poured into the molten fats, with continued vigorous stirring. If no vessel is available of sufficient size to hold the whole of the water needed to dissolve the soda, the latter is dissolved in a little water and added to the fats, the rest of the water being heated in the dissolving pan and run into the mixture by degrees. A still better plan is to dissolve the soda in separate portions and pour the solutions into the fat.

The mixture of fats and soda solution must be stirred in such a manner as to ensure the uniform distribution of both the fats and the soda; and this entails some little skill. The

best way is to set the fat in violent motion and then run the hot soda solution in as a thin stream.

Another very useful practice is to project both the melted fats and the soda solution through separate pipes to produce a fine jet of each, and then mixing them by means of the stirrers.

Stirring is continued until the mass begins to thicken, and a trial sample sets completely within a short time. The finished grease is then ladled into receptacles holding a definite quantity, *e.g.* 10, 20, or 30 lb., and left to set therein.

Palm oil and soda greases are for the most part not brought into direct contact with the surfaces to be lubricated, but are generally put into grease boxes mounted immediately over the axles to be greased, and provided with a hole in the bottom through which the lubricant can find its way to the working parts.

Owing to the heat liberated by friction, the grease in the boxes is partially melted after the wheels have turned a few times, or at anyrate it will have softened enough to allow it to pass through the hole aforesaid and grease the axle. The best greases for this purpose are such as assume a consistency resembling that of thick cream.

According to the time of year at which the grease is to be used, so must its composition be modified. If the temperature of the air—and consequently that of the machine parts to be greased—is high, the grease will readily melt, and will therefore become too thin and run to waste. On the other hand, in cold weather the grease will keep very firm, and the amount melted by the heat of friction will be insufficient for proper lubrication.

To obviate this difficulty, the proportions of the fats are altered for the various seasons; in summer, greases of higher melting point are used, *i.e.* those containing a larger quantity of tallow; whilst for the winter, more readily liquefiable greases

are employed, a smaller quantity of tallow being taken, and occasionally even a portion of this is replaced by a liquid fat, such as train oil or rape oil.

Some makers are not content with producing two varieties of grease for summer and winter use respectively; but also prepare a third grade suitable for spring and autumn. Indeed, such an intermediate grade is highly advisable for countries where the extremes of summer and winter temperature are great. For Italy, the south of France, England, and northern Germany for instance, two grades of grease would be sufficient; but for south Germany with its hard winter, hot summer, and mild spring and autumn, three are advisable.

Recipes for palm oil and soda greases for the different seasons are given below; and it may be stated again that the melting point of these greases can be readily modified by altering the proportions of the fats of high and low melting point.

YELLOW PALM OIL AND SODA GREASE

1. *For Winter Use*

Tallow	750
Palm oil	500
Sperm oil (rape oil)	70
Soda	228
Water	2600

2. *For Spring and Autumn Use*

Tallow	800
Palm oil	500
Sperm oil (rape oil)	55
Soda	222
Water	2500

3. *For Summer Use*

Tallow	900
Palm oil	500
Sperm oil (rape oil)	44
Soda	216
Water	2450

The lower the temperature, the more can the proportion of fat be diminished and the water increased, the converse being the case in summer. Train oil can be used instead of the dearer sperm or rape oil, but it must first have been specially treated.

When train oil is exposed to a moderately low temperature, about 40° F., a considerable quantity of hitherto dissolved fat separates out, the remaining liquid being more fluid than before, and specially adapted for adding to the above greases, whilst the solid portion can be utilised in soapmaking or for the preparation of special lubricants.

YELLOW PALM OIL, SOAP, AND SODA GREASES

1. *For Winter*

Palm oil	160
Soap	50
Soda	16
Water	540

2. *For Summer*

Palm oil	160
Soap	50
Soda	20
Water	360

The palm oil is first melted and then mixed with the soap; when this also is melted, the soda dissolved in 40 or 60 parts

of hot water is run in and well stirred up, the remainder of the water being incorporated with the mass, which is kept hot throughout. When all the water is in the pan, the contents of the latter are poured into a vat and stirred until they begin to set.

Another way of preparing these greases is by melting the fat and soap together in a pan, mixing them by stirring. Rape oil, which is rather dear, may be replaced by an equal quantity of train oil. Horse fat is recommended by some, but raises the melting point of the grease more than the liquid fats.

The soda is dissolved in the necessary amount of water in a second pan, the solution being heated to boiling and then mixed with the melted fat in a third vessel by stirring, this being continued as long as the consistency of the mass will allow.

A better class of grease is compounded of palm oil and rape oil, the soda being replaced by a corresponding amount of caustic soda. This grease does not contain any emulsion, but is a true soap grease, part of the fat being saponified by the caustic alkali.

AMERICAN PALM OIL GREASES

	A	B
Tallow	150	100
Palm oil	100	160
Soda	25	35
Water	160	300

FRENCH PALM OIL GREASES

	A	B
Tallow	380	280
Palm oil	125	100
Rape oil	65	70
Soda	25	20
Water	420	500

BELGIAN PALM OIL GREASES

	A	B
Palm oil	210	380
Tallow	...	750
Soap	85	...
Colza oil	...	200
Soda	15	50
Water	700	1300

This grease, which is both cheap and efficient, is characterised by containing three fats, tallow, palm oil, and colza oil in its composition.

AXLE GREASES FOR VERY HEAVY WAGGONS

1. *For Winter Use*

Tallow	420
Palm oil	840
Soda	140
Water	4200

2. *For Summer Use*

Tallow	420
Palm oil	490
Soda	35
Water	2300

The above are calculated for severe winter weather and high summer temperatures. For milder winter climates the proportion of soda may be somewhat reduced and the palm oil increased.

CART GREASE

Palm oil	210
Tallow	85
Soda lye	65
Water	920

The palm oil and tallow are melted together, the mixture rendered uniform by stirring, and the soda lye added. The density of the latter should be 20–21° Bé., that is to say, the Baumé areometer should sink into the solution down to the 20° or 21° mark on the scale.

After the soda lye has been stirred in, the water is added, and the mass is stirred until uniform, whereupon it is ladled out into vessels to set.

GREASE FOR WOODEN MACHINERY

Tallow	30
Palm oil	20
Train oil	10
Graphite	20

The fats are melted by moderate warmth, and the graphite, which has been reduced to the finest powder and then levigated, is intimately mixed therewith by protracted stirring.

In respect of the quantities consumed, the palm oil greases may be regarded as the most important of all lubricants, since they are employed, to the exclusion of all others, on many railways, and are often used for large machines as well.

CHAPTER VII

Lead Soap Lubricants

THE lead salts possess the property of saponifying fats or fatty oils to form fairly solid compounds, known as lead soaps, which are hard in the cold and smeary at the ordinary temperature, but attain the necessary degree of fluidity when warmed by friction.

This latter property is highly important in the case of the axles of vehicles, since it reduces the loss of grease, by dropping, to a minimum.

For the preparation of these lubricants it is first of all necessary to make a solution of basic lead acetate, or sugar of lead, which is then incorporated with a suitable proportion of fat.

The solution is prepared from:

Sugar of lead	10
Litharge	10
Water	110

which are boiled 1½–2 hours, with repeated stirring, at the end of which time the mass is left to rest, and the clear liquid is drawn off. The latter is made up to 100 parts by weight, by the addition of water, and after being warmed to about 120°–140° F., is mixed with common fat (rape oil and pork fat, or neatsfoot oil), in the following proportions:

Sugar of lead	100
Rape oil	80
Pork fat	80

The resulting preparation should be of a uniform grey colour, and when melted should set again at 85°–105° F.

A large number of so-called "antifriction greases," regarded as secret preparations, are in the main only lead soap prepared according to this recipe or on similar lines. Owing to its rather high melting point, this grease is less suitable for ordinary carts than for quick-running axles (railway wheels, flywheel shafts, etc.).

The preparation of lead soap greases can be greatly simplified by proceeding in the following manner. The ingredients are:

Sugar of lead	20
Litharge	10
Water	225
Vinegar	1

The water and vinegar are placed in a covered vat, and the sugar of lead and litharge are placed in two linen bags and immersed in the liquid, being left therein for a week. The clear solution of lead acetate drawn off at the end of this time is placed in a vat and mixed with—

Rape oil	500
Pork fat	750

which have previously been melted together in a pan and heated to about 250° F. The mixture is well stirred and left to stand for several days. In about four days (sometimes two) it will have set, and will then be ready for use.

LEAD OLEATE AXLE GREASE

Palmer's Patent Axle Grease consists principally of lead oleate, and is therefore a lead soap, closely resembling apothecaries' sticking plaster in composition.

In the manufacture of stearine candles, the crude fatty acids are subjected to heavy pressure, which squeezes out oleic acid containing stearic acid and palmitic acid in solution. When the crude oleic acid is exposed to low temperatures a further large portion of the dissolved solid fatty acids crystallises out; and the crude oleic acid of commerce is a yellow to brown liquid, mostly with a disagreeable smell. In Germany it is known as Oel—or Oleinsaure, and in France as acide oleique, both of which names express its composition; but in England it is frequently called "tallow oil," a term which may give rise to confusion, inasmuch as the same name is (correctly) given to the oil obtained by pressing refined tallow that has been stirred before setting. True tallow oil is a much more valuable and expensive article than oleic acid.

In order to produce lead soap from oleic acid the latter is placed in a pan that is mounted on a brickwork setting in such a manner as to prevent the contents coming into direct contact with the heating flame. The pan is also provided with a close-fitting lid, to prevent the flame spreading in the event of the oleic acid becoming ignited.

The oleic acid is heated to boiling, whereupon litharge, in a finely ground condition, is run in through a narrow pipe and stirred continuously. The usual proportion of litharge is from one-fifth to one-fourth the weight of the oil.

After all the litharge is in, the stirring is continued for twenty to forty minutes, the temperature being then gradually lowered. Such of the litharge as is not dissolved by the oleic acid settles down to the bottom of the pan, and is left there until the next operation. The clarified liquid is ladled off and left to set, preferably in sheet-iron tanks.

On quick-running axles which generate a good deal of heat, this grease soon attains the requisite fluidity, but it is too thick for those running at low speeds.

The melting point of this very useful lubricant is best lowered

at the time of preparation, by the addition of cheap fats like horse fat or train oil. The hot lead oleate obtained as above is ladled out into a separate vat, already containing the fat or train oil, and the mixture is quickly stirred up together. The lower the desired melting point, the larger must be the proportion of added fat. Consequently for summer greases a large quantity of fat must be added, about 20–40 parts per 100 of lead oleate being usually sufficient.

CHAPTER VIII

True Soap Greases

THE soap greases, properly so called, are prepared with ordinary soft soap (a compound of potash with fatty acids), or from fats and potash, these forming the emulsions already referred to. Although these greases are occasionally very useful, their employment is restricted, owing to the risk that lack of care in their preparation may leave certain quantities of potash or caustic alkali uncombined, to the great injury of the metal, which is extensively corroded.

CHARDON'S SOAP GREASE

Soft soap	10–50
Lye or water	90–50

This peculiar lubricant, which is claimed to specially lessen the wear and tear of the bearings—and if this claim were tenable would be in reality highly commendable—is, according to its inventor, much cheaper than oil. The different proportions of soap and water vary with the season.

The use of lye, however, for dissolving the soap, appears objectionable, if only for the reason that caustic alkalis exert a corrosive action on the metals and metallic alloys—cast iron, steel, bronze—of which machine parts are generally made. In a properly made soap there is no free fatty acid, so that any added caustic alkali acts on the metal and soon causes it to rust. That Chardon's grease is of little value is shown by the

circumstance that, according to the recipe, it is immaterial whether water or lye be taken. Anyone possessing even a slight knowledge of chemistry will know what a wide difference exists between a lubricant consisting of soap and water and one containing soap and lye.

TALLOW OIL AND SOAP GREASE

Tallow	420
Olive oil	360
Potash	60
Water	650

The potash is dissolved in water, the solution heated to boiling, and the whole of the fat is added at once, the fire being made up so as to keep the whole in a fluid state. Boiling is continued, with constant stirring, until complete saponification is indicated by the thickening of the mass and the way in which a sample will draw into threads on cooling. The resulting product is, in a chemical sense, really a dilute solution of potash mixed with an excess of fat, and may therefore be regarded as an emulsion lubricant in the true sense of the term.

CARRIAGE AXLE GREASES

	A	B
Tallow	500	500
Linseed oil	500	450
Pine resin	500	500
Caustic soda lye . . .	315	500

Both preparations, when suitably stirred during preparation, form solid masses of the constituency of salve, and yellow in colour. They are easily distributed on the axles and lubricate well. The resin is melted first, the tallow and linseed oil being then added, and when these have formed a uniform mixture,

the caustic soda lye is added by degrees. The lye is used moderately strong, and the firmness of the grease can be heightened by increasing the concentration of the alkaline solution.

From the chemical standpoint this somewhat expensive lubricant is a mixture of ordinary soap, resin soap, and emulsified fats.

CHAPTER IX

Caoutchouc Lubricants

DOULON'S CAOUTCHOUC GREASE

Train oil	200
Caoutchouc	20

THE train oil is heated in a pan until it begins to decompose, this condition being revealed by an ebullition resembling boiling and by the evolution of a disagreeable smell, the caoutchouc—cut into small pieces—being introduced by degrees and the entire mass vigorously stirred after each addition.

For ordinary purposes this grease is inapplicable, owing to the high price of caoutchouc, the more so because lubricants of at least equal efficiency can be prepared at a far cheaper cost.

The author cannot refrain from saying here that a good deal of deception is practised with regard to the recipes for preparing certain lubricants, especially in respect of the alleged economy of the products when used, statements being made on this point that any expert will characterise as inaccurate.

CAOUTCHOUC MACHINE GREASE

Caoutchouc	20
Linseed oil	1000

Twenty parts each of caoutchouc and linseed oil are first melted together, another 20 parts of oil being stirred in as soon

as the mixture begins to disengage vapour. Subsequently the rest of the linseed oil is added, 100 parts at a time.

AMERICAN CAOUTCHOUC GREASE

Caoutchouc	4
Oil of turpentine	8
Rape oil	114
Soda	16
Glue	4
Water	50

The caoutchouc is dissolved in the oil of turpentine, whilst the rape oil is first mixed with the soda, water, and glue, and then boiled, the caoutchouc solution being stirred into the homogeneous mixture.

Strictly speaking, the expression "caoutchouc solution" is wrong, since only a small portion of the caoutchouc is really dissolved, the rest being merely strongly swollen. The finished mass needs to be stirred for a very considerable time in order to get it perfectly homogeneous.

CAOUTCHOUC ADHESION GREASE

Caoutchouc	36
Oil of turpentine	72
Cabinetmaker's glue	10
Tallow	80
Soda	72
Water	900

This peculiarly compounded grease is prepared as follows: The caoutchouc is first dissolved in the oil of turpentine at a temperature of about 250°–300° F., the tallow being melted in another pan, mixed with the powdered soda, and the water stirred in. When all has become homogeneous, the caoutchouc solution is run in, stirred, and the whole left to set.

CAOUTCHOUC AND GUTTAPERCHA GREASE

Caoutchouc	50
Guttapercha	50
Oil of turpentine	100
Tallow	1000

The caoutchouc and guttapercha are dissolved in the oil of turpentine and heated strongly, the tallow being then added by degrees. The use of the expensive ingredients caoutchouc and guttapercha, makes this a very dear grease.

CAOUTCHOUC AXLE GREASE

Palm oil	20
Train oil	100
Caoutchouc	2
Litharge	2
Sugar of lead	2

The caoutchouc is cut into small pieces and heated with the train oil to about 390° F., the litharge and sugar of lead being then added and the heating continued for an hour longer. Finally, the palm oil is stirred into the still hot mass.

CAOUTCHOUC AND FAT GREASE

Caoutchouc	5
Palm oil	100
Rape oil	100
Tallow	50

The caoutchouc is dissolved in the rape oil by the aid of a high temperature, and the filtered solution is incorporated with the solid fats. (The author has found, by experiment, that actual filtration of the mass is impracticable, it being difficult to strain even through a linen cloth.)

CHAPTER X

Other Solid Lubricants

THE following recipes relate to a few lubricants that do not belong to any of the foregoing groups, but have proved useful. Such recipes have been omitted as gave unsatisfactory results when tried, or appeared from their constitution to be merely arbitrary compositions recommended by persons ignorant of the subject, and probably never used at all.

ASPHALTUM AXLE GREASE

Asphaltum	32
Black pitch	8
Petroleum	8
Litharge	8
Water	80

The asphaltum and pitch are first melted together in a pan, the petroleum being then added until the mass has become uniformly fluid. The litharge is next added, and finally the water is run in in small quantities, the whole being stirred until perfectly uniform. The asphaltum and pitch give this grease a lustrous black colour and a peculiar bituminous smell. The fluidity of the mass can be increased or diminished by correspondingly varying the proportion of petroleum.

NAPHTHALENE GREASE

Naphthalene	100
Rape oil	50–100

The naphthalene—a crystalline hydrocarbon recovered from coal tar—is melted and stirred up with a larger or smaller quantity of rape oil, the product varying in consistency between firm, buttery, and fluid, and forming a useful lubricant. The expensive purified naphthalene is not meant here, purity not being an essential feature for the purpose in view; so that the crude article, which is very impure, is sufficient. These remarks apply equally to paraffin.

RESIN MACHINE GREASE

Pine resin	100
Resin oil	50
Pork fat	300

The resin and resin oil are melted together, and the pork fat is stirred up with the liquefied mass.

GRAPHITE AXLE GREASE

Tallow	36
Pork fat	9
Palm oil	9
Graphite	2

Graphite is of a steely grey colour, and imparts a peculiar grey-black colour to the grease.

This graphite axle grease is a very efficient lubricant, and is frequently used in Belgium and England as the sole grease for waggon axles.

GRAPHITE GREASE FOR QUICK-RUNNING AXLES

Tallow	100
Graphite	100

This is specially suitable for greasing the shafts of circular saws, ventilating fans, etc., and indeed for any axles running at high speed under small load.

CHAPTER XI

Liquid Lubricants

THE liquid lubricants possess many important advantages over the greases, and in consequence are often preferred by railway companies and machinery makers. Their chief superiority is that they do not require such complicated appliances (grease boxes) in use, they begin to act as soon as they are applied, without needing the heat generated by friction to make them sufficiently fluid; and, besides, the oiling vessels can be of a simple type, even on the axles of vehicles. Finally, they exhibit the valuable feature of having their consistency less affected by the temperature of the air than is the case with greases.

The best materials for the preparation of the liquid lubricants are:

1. Rape and colza oils.
2. Olive oil.
3. Resin oil, either alone or in association with lime or certain products of dry distillation (paraffin).
4. Train oil.
5. Neatsfoot oil and bone oil.
6. The so-called mineral oils (solar oil, coal oil).
7. Petroleum and ozokerite.
8. Soap solutions.

CHAPTER XII

Lubricating Oils in General

OILS coming from the press are unsuitable for use as lubricants, and have to be put through a special treatment known as refining.

It will be easily understood that by the powerful pressure to which the cells enclosing the oil are subjected in the press, not only are the cells ruptured, allowing the oil to escape, but particles of solid vegetable matter, mucilage, albumin, and other compounds are expressed with the oil, and make the latter, as it comes from the press, turbid and slimy (instead of clear and transparent), so that it soon turns rancid.

Attempts have been made to clarify the oil by leaving it to stand for a considerable time, to allow the impurities to settle down. The oil, however, being somewhat thick, and the solid particles of rather low density, differing little from that of the oil itself, the consequence is that their deposition is a very slow process, and is never quite complete, however long the oil is kept in store.

Endeavours to clarify the oil by filtration are also unsuccessful, the oil running through very slowly even at first, whilst the mucilaginous substances present soon clog the pores of the filtering medium and stop the process entirely.

If a really and permanently efficient filter could be constructed for treating oil it would be extremely useful in the manufacture of lubricating oils. Oil that is filtered while fresh from the press is perfectly neutral if kept out of contact

with air, that is to say it contains no traces of free fatty acids. This must be regarded as a very great advantage, since the free fatty acids are able to strongly corrode metals and thereby contribute to the rapid wear of the machine parts.

Latterly a number of fatty oils have also been obtained, by extracting the oil-bearing materials (vegetable matters) with benzol, carbon disulphide, etc. Oils recovered in this way are, as a rule, free from uncombined fatty acids, and therefore suitable for use as lubricants.

Pressed oils, however, have to be first refined, for which purpose many suggestions have been advanced, though some of them, for which great results are claimed, are evidently destined to failure, when examined from a chemical point of view, their originators being destitute of chemical knowledge.

Bearing in mind the enormous importance oils have now attained as lubricating agents — many railways using oil exclusively, both for waggons and locomotives — the author considers it highly desirable to treat of the refining of oils very fully, more especially because, in addition to the large increase in the consumption of lubricating oils by the railway companies, their application has now extended to nearly all kinds of steam engines, spinning, weaving, sewing and knitting machines, cycles, and in short all the finer mechanical instruments.

CHAPTER XIII

Refining Oils for Lubricating Purposes

THE SULPHURIC ACID PROCESS

THE ordinary method of refining pressed oils is with sulphuric acid. When a crude oil, as it issues from the press, is intimately mixed with a certain quantity of sulphuric acid, a strong reaction is produced, the time taken for this to ensue depending on the amount of acid used.

At first the temperature of the mixture rises fairly considerably, and the oil assumes a greenish tinge, the colour of the mixture gradually deepening through brownish green into brown, and finally into black.

The cause of this colour change is that the sulphuric acid first attacks and decomposes the greenish colouring matter peculiar to most oils, and especially to the rape and olive oils frequently used for lubrication. At the same time the accompanying cell substance, vegetable mucilage, and other foreign matters, undergo alteration, being gradually decomposed and carbonised by the hygroscopic action of the sulphuric acid.

The very finely divided carbon thus produced causes the gradual change of colour from brown to black. During the operation, which must be carried on in lead-lined vessels, as the acid would corrode other materials, the mixture is kept stirred, and in many works the reaction is assisted by heat. As all chemical processes are accelerated by warmth, so also the destruction of the foreign admixtures in the oil is effected

more rapidly the higher the temperature of the oil under treatment.

It is advantageous to heat the oil by steam, passed through a leaden coil in the vat, and raising the temperature to about 140°–160° F. The higher the temperature of the oil, the sooner is the refining process over, and the smaller the amount of acid required.

This last fact is a very important one for the manufacturer of lubricants, not only on account of the saving of acid, but also because of another process operating through a direct action of the sulphuric acid in the oil itself.

The quantity of acid used may rise as high as 3 per cent. of the oil to be refined. It is run, in the form of a thin stream, no thicker than a quill, into the warmed oil, and an attempt is made to secure the most intimate possible admixture of the oil and acid, by keeping the stirrers running at a high speed. After the operation the liquid is left to rest, and it soon separates into two layers, the oil, which is much thinner than before and is partially bleached, floating on the top, whilst underneath it lies the acid, which has become diluted by the absorption of water and is coloured a deep black by the finely divided carbon in suspension.

The oil is syphoned off from the acid layer, and is freed from accompanying traces of oil by washing. In this operation it is necessary to pour the oil, as a thin stream, into warm water, which is kept in rapid motion by stirrers, the oil being afterwards separated from the water and put through the same treatment again. By careful and repeated washing it is possible to purify the oil to such an extent that no trace of free sulphuric acid can be detected by even the most delicate chemical tests.

This, the ordinary practice in oil refineries, yields an oil that is perfectly clear, thin, and pale in colour: but it possesses one property that forms an important obstacle to its use for lubrica-

tion. Although the sulphuric acid has been removed by careful washing, the oil is never neutral, but always contains a considerable quantity of free fatty acids which would strongly corrode the metallic machine parts.

This peculiarity is due to a reaction of the sulphuric acid on the constituents of the oil itself. Like most fats, oils consist of a compound of glycyl oxide with various fatty acids, the most usual of these being stearic, palmitic, and oleic acids.

When a fat or oil is treated with caustic alkalis, caustic potash, caustic soda, quicklime, or lead oxide, the glycyl oxide combines with water to form glycerine, and separates out, whilst the fatty acids combine with the base (soda, potash, lime, or lead) and furnish the compounds we call soaps.

When sulphuric acid is brought into contact with fats or oils, a process analogous to saponification occurs, and it is therefore, though erroneously, spoken of as saponification by sulphuric acid. The oil is decomposed in such a manner that glycerine separates out, and the sulphuric acid enters into combination with the oleic acid.

This compound of sulphuric acid and oleic acid, however, is so very unstable that it can be broken up again into sulphuric acid and oleic acid by the action of a large volume of water. The sulphuric acid passes away in the water, but the oleic acid dissolves in the oil and imparts acid properties to the latter. Machine parts lubricated with such an oil soon reveal traces of the chemical action of the fatty acids present.

Hence, in order to refine oils intended for lubricating purposes, another method must be adopted than that which is suitable for lamp oils, etc. An endeavour is made to reduce the quantity of sulphuric acid to a minimum, not more than 1 per cent. of the weight of the oil being used. With such a small quantity of acid the refining process is greatly retarded, and must be accelerated by warmth. The following method on these lines

has always given excellent results with a minimum quantity of sulphuric acid.

The freshly pressed oil is placed in a large lead-lined vat, fitted with a steam coil and stirrers. By means of high-pressure steam the oil is quickly heated to the boiling point of water, whereupon the sulphuric acid is run in. The stirrers are kept running at good speed for a considerable time, until the whole liquid has turned black. As soon as this is noticed, the steam is turned off, but the stirrers are kept at work half an hour longer.

The dark-coloured liquid is at once transferred to another vat, to be washed with water, the mixture of oil and water being stirred until all the former is in. This done, the stirring is stopped, whereupon the liquid separates into two layers, the oil floating on the top, whilst the lower one consists of water acidified with sulphuric acid, and is of a dark colour, owing to finely divided carbon. This washing process is repeated, a third treatment being given if necessary, but no interval should be allowed between them.

This short treatment with sulphuric acid, followed by a quick separation of the acid and oil by washing, limits the action of the acid to the destruction of the foreign matters present, without allowing it to extend to the alteration of the oil and consequent formation of oleic acid. As a rule, two washings after the acid treatment will suffice to completely free the oil from all traces of acid.

The complete removal of the sulphuric acid from the oil is also necessary, since this, the strongest of all acids, has an extremely energetic action on metals. The freedom of the oil from sulphuric acid is detected by shaking up the liquid with a little barium chloride solution. If the oil remains unchanged, no free sulphuric acid is present; but if it becomes opalescent or assumes a whitish tinge, this is proof positive that the oil contains sufficient free sulphuric acid to act injuriously on the

metal of any machine it may be used to lubricate. In order to make quite sure, however, the barium chloride solution should have first received an addition of one-fourth or one-fifth of pure hydrochloric acid, this being necessary to dissolve the precipitate or turbidity that would be formed by the presence of phosphates in the oil, and might otherwise be mistaken for that produced by sulphuric acid.

In addition to the sulphuric acid method of refining, which though somewhat troublesome is still the best, various others have been proposed. Of these, attention is best merited by those in which the crude oil is treated with a solution of tannin, with caustic potash, or with sulphuric acid and zinc, with zinc oxide or lead oxide (litharge).

REFINING WITH TANNIN

In this method the oil is heated to the boiling point of water, and intimately mixed, by stirring, with about 5 per cent. of a strong solution of tannin. This solution is more simply prepared by boiling fresh oak tan with its own weight of water for half an hour, and straining the decoction through a fine cloth.

Though the tannin partially precipitates the foreign substances present in the oil, it does not effect their complete separation, the colouring matter of the oil, for instance, being left unchanged, so that the refined oil is always dark coloured, which lowers its apparent value.

REFINING WITH CAUSTIC POTASH

The method of refining oil with caustic potash is based on the principle that very strong potash lye, when brought into contact with the oil for a short time only, completely destroys the foreign impurities without attacking the oil to any particular extent.

The oil to be refined is placed in a large pan, and after being

heated to the boiling point of water, is treated with an addition of 2–3½ per cent. at most of highly concentrated caustic potash lye, with constant stirring.

Within a short time the liquid grows very turbid, frothing considerably and throwing up a flocculent scum, which, however, soon falls to the bottom, leaving the clear oil floating on the surface.

Since the mucilaginous matters are partly dissolved in the lye and partly coagulated, in a form resembling coagulated albumin, they are easily separated from the refined oil.

The best way of effecting this separation is by means of a flannel filter, the rough side of which is turned toward the oil. In this way the oil is quickly obtained as a clear liquid.

In this method also, which is most frequently employed for refining rape oil, the minimum quantity of the refining agent (caustic potash) should be used, since a large quantity would entail an excessive waste of oil.

Thus, if more of the potash be used than is necessary for eliminating the foreign impurities, the alkali will act directly on the oil and convert a portion of it into soap, which remains in solution in the liquid separated from the oil. This does not matter so much in the case of oil refineries that are connected with soapworks or are able to dispose of their spent lye to a soap boiler, since in such event the soap solution can be utilised; otherwise the cost of refining in this way works out rather high.

It is impossible to make a definite statement as to the smallest quantity of lye that will suffice for a given oil, since this depends on the amount of impurities present. Oil coming fresh from the press, especially from a powerful hydraulic press, will naturally contain a larger proportion of foreign substances than such as has been obtained by moderate pressure and then stored for some time, so that in the former case a larger quantity of potash will be needed than in the latter. The only

way of ascertaining the minimum is by making trials with small quantities of the oil to be refined, and by practical experience.

The advantages of the caustic potash method are not unimportant, the operation proceeding quickly and satisfactorily, and yielding an absolutely acid-free product, every trace of free fatty acid being eliminated by the alkali.

Provided the operation be performed in a wooden vat heated by steam, or in a clean iron pan if steam is not available, the oil will not darken in colour. On the other hand, copper pans should be avoided, the metal being strongly attacked by the alkali, and the oil coloured green by the dissolved copper.

Caustic potash may be replaced by caustic soda, with the same result, the solid commercial caustic being used. The best way to prepare the highly concentrated lye is by placing the lumps of caustic soda in an iron vessel, and covering them with an equal weight of water. Solution takes place very quickly, the liquid growing very hot. Owing to the corrosive action of these highly concentrated lyes, they require very careful handling, since a drop falling on the skin will immediately destroy it.

The sole objection that can be urged against the method of refining with caustic potash is that the oil is not bleached, but retains its original colour, and may even grow darker, especially when the proportion of caustic lye is increased.

Although the colour of a lubricating oil has no influence on its lubricating properties, it is none the less desirable to obtain as light a colour as possible, since this, in conjunction with brightness, is looked on (and not altogether without reason) by the consumer as an indication of careful refining.

In this connection the sulphuric acid method, when well carried out, is highly serviceable, and furnishes a product of unimpeachable quality. Other methods have been proposed with the same object in view, but with only partial success.

After numerous experiments in this direction, the author has

ascertained that two methods are really useful, but furnish dissimilar products. These are the methods employing either zinc oxide or litharge.

REFINING WITH ZINC OXIDE

In this method, which is chiefly employed for rape oil, the crude oil is first treated, as already described, with a very small quantity of sulphuric acid. The oil turns dark coloured, passing from brown into black, separates from the acid, and is repeatedly washed with hot water, until it ceases to give a precipitate with barium chloride.

As already mentioned, in this treatment the action of the acid on the oil forms a compound of sulphuric and oleic acids, which is decomposed into these constituents again when treated with a large volume of water. Consequently the refined oil invariably contains a certain quantity of free oleic acid, which would strongly corrode the machine parts; and it is to remove this oleic acid that use is made of the property of zinc oxide of combining with the acid in question to form an insoluble compound, zinc oleate.

Zinc oxide is obtainable at a low price in commerce as zinc white, a heavy white powder. The quantity required for the purpose in view is 1 per cent. of the weight of the oil under treatment. To ensure the most complete diffusion of the zinc oxide through the oil, the former is first stirred up with three to four times its own weight of the oil, until a white, milky fluid is obtained, which is then run into the bulk of the oil, with constant stirring.

After remaining at rest for several hours, the greater portion of the unaltered zinc oxide and the zinc oleate will have sunk to the bottom, but as it would take too long to wait for complete clarification, the oil is then filtered.

It has also been proposed to place the oil in a vessel containing zinc turnings or scraps. True, these soon become coated with a white film of zinc oleate, and the oil is purified; but it

is very difficult to obtain a clean surface on the metal again, and so fit it for the next charge of oil, and therefore the treatment of the raw oil with zinc oxide is preferable.

When the operation has been carefully performed the oil refined by the zinc white process possesses, in a high degree, all the necessary properties of a good lubricating oil; it is very light in colour, and can be obtained almost colourless, if the oil was originally pale; it is also inactive toward metals, and will not become acid, even after prolonged standing in the air. Being fairly thin it is very suitable for oiling fine machine parts, since it does not thicken when the machine is left unused for some time.

To obtain a suitable lubricant for coarser machines, the rape oil must be mixed with tallow, palm oil, or some other fat capable of rendering it less fluid.

REFINING WITH LITHARGE

When lead oxide is used for refining, the method adopted is, in the main, precisely the same as with zinc oxide. There is, however, some difference in the behaviour of the two oxides, the resulting lead oleate being less easily separated than the zinc compound, since it remains dissolved in the oil. The latter is, it is true, perfectly free from any trace of free acid, but is rendered more viscous by the presence of the lead oleate; and in fact, if more than the necessary amount of lead oxide be used, and the reaction be assisted by heat, the oil may thicken to the consistency of lard or soft butter. This change generally supervenes when the oil contains $2\frac{1}{2}$–3 per cent. of lead oxide.

The soft masses formed by treating rape oil with litharge in this way make excellent lubricants, and are specially prepared for certain purposes.

Colza oil (Fr. Huile de Colza; Ger. Kohlsaatoel) is refined in the same way as rape oil; and in fact these two oils are very similar in their properties, though they can be readily distinguished by an expert.

Some considerable confusion exists in commerce respecting the nomenclature of rape and allied oils. One kind, known as Rubsen oil, is obtained from the seeds of *Brassica napobrassica*; whilst a second grade, rape oil proper, is derived from the seeds of winter or summer rape, the respective plants being *Brassica napus oleracea* and *Brassica napus praecox*. Colza oil is from the seeds of *Brassica compestris*.

REFINING OLIVE OIL AND RAPE OIL

Since petroleum has displaced nearly all the fatty oils for lighting purposes, olive oil is obtainable at prices enabling it to be largely used for lubrication.

The process of refining this oil is exactly the same as that already described for rape oil. The sulphuric acid method is the one generally adopted, followed by an extremely careful washing with water, hot at first, and afterwards of ordinary temperature. The zinc oxide or litharge treatment is less often practised. It would seem that the combination of the oleic acid and glycerine is more stable in the case of olive oil than in rape oil: at least this conclusion is deducible from the fact that, when small quantities of sulphuric acid are used, the oil is thoroughly refined without any detectable traces of free oleic acid being formed.

Olive oil is also often used for lubricating the finest and most delicate machinery, for example as clockmaker's oil, and for this purpose it is usually desired to be perfectly colourless. The sulphuric acid method of refining, however, yields a product that is coloured golden yellow at least, just like the best quality oil for culinary purposes, the colouring matter of the oil resisting the action of the acid almost completely.

Nevertheless, it is not difficult to obtain even the common qualities of olive oil in a perfectly colourless condition; for though the colouring matter resists the action of chemical reagents, it can be completely destroyed by protracted exposure

to light, especially direct sunlight, so that the oil can be obtained as a perfectly water-white liquid.

The bleaching of olive oil, which is only necessary in case it is to be used for the finest lubricants, can be effected by keeping it in vessels of clear white glass, that are tightly closed and set in a sunny place. The smaller the bottles, the shorter the time required for complete bleaching.

Olive oil is in every respect an excellent lubricant. When properly refined it will keep for several years before commencing to thicken. (It may be remarked here that the technical name for this thickening of lubricating oils, namely, "resinification," is erroneous, the formation of resin occurring solely in the case of ethereal oils.) Olive oil possesses the additional valuable property that it contains no free oleic acid, and that the mucilaginous impurities present are readily destroyed in refining.

Any fine, non-drying oil can be used as a lubricant unless the price is prohibitory. Manufacturers should endeavour, in their own interests, to ascertain whether other oils, in addition to those already mentioned, can be utilised for this same purpose on an extended scale. Ground-nut oil, or arachis oil, clearly exhibits the properties of an excellent lubricant, and is also obtainable in commerce at relatively low prices; but though it has been used for this purpose, its application has not been on any large scale.

The same properties are also possessed by sesame oil and beechnut oil. The latter, for instance, could be produced in very large quantities in Germany, where the beech is one of the chief forest trees. The author desires particularly to direct the attention of lubricating oil manufacturers to the oil obtained from beechnuts in the ordinary manner, since his own experiments, conducted on an extensive scale, shew this oil to be admirably adapted for the purpose, and the raw material, beechnuts, could be readily obtainable in large quantities.

CHAPTER XIV

Cohesion Oils

It cannot be disputed that some lubricants, the liquid varieties in particular, have an unpleasant tendency to be wasteful in use, so that when there is a large number of axles in constant use, as is the case on railways, for instance, the expense of lubrication becomes very great, though in other respects there is no fault to find.

To remedy this defect and reduce the consumption of lubricant to a minimum, the so-called cohesion oils have been compounded, which are, quantitatively, more economical than any other kind.

As the name implies, these lubricants are distinguished by possessing a lower degree of fluidity than the ordinary liquid grades.

Opinions vary on the efficiency of these cohesion oils, for while some large consumers of lubricants declare themselves so content with them as to prefer them to refined olive or rape oil, others do not give the same favourable report, but complain that the cohesion oils make the bearings and lubricating appliances very dirty, and that the oils deposit such a large amount of sediment as to prevent any efficient lubrication.

The author's opinion, from his own experience in the matter, is that an oil exhibiting these last-named properties must be classed as bad. Some makers, with the idea of improving their products as much as possible, have continued to increase the cohesive properties until some of the oils placed on the

market have been almost too viscous to pour out of the can, and would draw out into threads like partly set glue.

Cohesion oils containing such an immoderate proportion of constituents producing viscosity, will readily deposit these as a sediment on standing, the resulting thick mass being unsuitable for lubrication.

Certain oils of the class in question were and are being put on the market as having been prepared by secret processes. The chemical examination of a number of these oils, however, shews that certain makers add colouring or scenting ingredients (sometimes both) that are quite inert as regards lubricating properties, and are used for the sole purpose of masking the properties of the other components and preventing their detection.

Nevertheless, despite these intentional misdirections, the skilled chemist is able to analyse these products; and the various experiments performed on cohesion oils of English, German, and American origin, clearly shew that they are all made from about the same fundamental materials.

Without exception, the basis of the cohesion oils is a more or less viscous fat, crude rape oil being most frequently used, train oil more rarely, whilst occasionally tallow, palm oil, neatsfoot oil, or other solid fat is added to reduce the fluidity.

In addition to the fats, these oils all contain variable quantities of resin oil, the amount ranging within wide limits; and experiments have shown that from 8 to 20 per cent. of resin oil can be used.

The substance employed for imparting the characteristic property of viscosity is ordinary American pine resin; and the larger the amount added, the higher the cohesion of the oil. The additions range from 8 to 15 per cent. of the weight of the fat; but it is inadvisable to exceed this latter limit, especially if the lubricant is to be used at low temperatures.

The preparation of cohesion oils is generally a simple matter.

The rape oil is gently warmed in a pan and mixed, when necessary, with the corresponding quantity of solid fats (palm oil, tallow, etc.). The resin oil is heated, almost to ebullition, in a second pan, precautions being taken to prevent ignition of the contents, and the resin, broken into small pieces, is added by degrees, one portion being allowed to dissolve completely before another is added. Solution must be assisted by stirring, to prevent any resin sticking to the bottom of the pan and burning there.

When the resin is fully dissolved, which does not take long, the solution is ladled into the pan containing the oil. The latter is kept constantly stirred; and when all the resin solution is in, the fire is put out, and the mass is stirred until it begins to thicken.

The following particulars give the composition of two cohesion oils, No. 1 being the thickest, and therefore suitable for quick-running, heavily laden axles, whilst No. 2 is suitable for lighter ones.

Other conditions being equal, No. 1 may be used in summer and No. 2 in winter.

COHESION OILS

	1.	2.
Raw rape oil	95	96
Refined tallow	5	4
Resin oil	12	4
American pine resin	12	8

CHAPTER XV

Resin Oils

WHEN a resin is heated above the melting point it begins to decompose and liberates gases and vapours, the latter condensing, when cooled, into liquid and solid products. This decomposition by heat is known as "dry distillation," and is performed on a large scale in the case of pine resin. The oily products thereby obtained are known in commerce as resin oils, or "rosin" oils.

These oils chiefly consist of hydrocarbons, with which a certain percentage of acid substances is always associated, which acid substances would corrode the metal of machine parts and form thick or soapy compounds, greatly retarding the work of lubrication.

In order to obtain a resin oil free from these objectionable properties, the distillation process must be conducted in such a manner that the distillate is entirely free from acids. This is accomplished by adding a certain quantity of quicklime to the resin in the still, this addition fixing the acids already present in the resin or formed during distillation, and allowing a resin oil to distil over perfectly free from acids, and therefore capable of being used as a lubricating oil without risk.

A compound of the acids and lime, a lime soap, is formed in the still, and remains there as residue. This compound is not capable of direct utilisation, and can only be made so by further treatment. On the other hand, if the 5–9 per cent. of

quicklime usually found sufficient be replaced by the same quantity of solid caustic soda, dissolved in its own weight of water, a useful product is obtained, namely, a resin soap, that can be either used direct as a soap or else added to cheap soaps prepared from fats.

By this means the loss sustained by the diminished yield of resin oil can be fully compensated.

Both solid and liquid lubricants can be prepared from resin oil, and, by the addition of suitable adjuncts, the consistency can be varied in any desired degree up to that of butter. This constitutes a great advantage for the various purposes the resin oil is intended to serve.

Thus, by the addition of suitable quantities of alkaline earths, resin oil can be modified into viscous to semi-solid masses. The alkaline earths proposed for this purpose are calcined magnesia and milk of lime.

For reasons of economy, however, the use of calcined magnesia has been abandoned, since the same results can be obtained by the cheaper and more easily procurable lime.

Since the introduction of large quantities of excellent American resin at low prices into the European market, this substance has been extensively used, and the dry distillation of this resin is made to furnish a whole series of chemical products, used partly for lighting, as solvents in varnish-making, as asphalt substitutes, and finally as a very important ingredient of many lubricants. The quantity of the products obtained by distilling a given weight of resin varies according to the time occupied in distillation, and also according to the nature of the resin itself. As a general rule, 1000 parts by weight of resin will furnish—

Light resin oil and acid liquor . .	88–100
Heavy resin oil	730–800
Asphaltic residue	110–182

The volatile distillates, partly consisting of unaltered oil of turpentine that was present in the resin, are used for lighting purposes, and as an excellent solvent for resin in varnish-making. The heavy oil is refined by repeated fractional distillation and treatment with soda lye, the crude resin oil having a disagreeable smell, a yellow to brownish colour, and a blue or green fluorescence. In refining the light resin oil, the products comprise pinolin and a violet oil that turns blue in the air—the so-called train oil or cod oil, which forms a very important component of many lubricants.

THE PREPARATION OF RESIN OIL

Resin oil is so extensively used in the production of lubricants that it seems advisable for manufacturers who are working on a large scale to prepare this ingredient themselves and sell the by-products. Originally the stills used for distilling resin to oil were of the usual simple form, heated by direct fire and connected with an ordinary condensing coil. Owing, however, to the fact that resin is a very poor conductor of heat, the melted resin at the bottom of the still easily got overheated, with the result that a large quantity of gas and pitch, but only a comparatively small amount of resin oil was produced.

To overcome this defect it is preferable to distil the resin with the assistance of superheated steam exclusively, since this method gives the highest yield of resin oil and entirely obviates the fire risk which is so imminent in the case of stills heated by direct fire.

When low pressure steam ($1\frac{1}{2}$–2 atmospheres) is passed through a coiled pipe mounted in a furnace and heated to redness, a steam temperature of 350°–400° C. is easily obtained, *i.e.* much higher than is needed for the distillation of resin. When this steam is passed in a suitable manner through the still, it will accomplish the dry distillation of the resin; and

the operation can be kept under perfect control by increasing or diminishing the supply of steam. A still for distilling resin by superheated steam is shown in Fig. 1, means being provided for separating the distillation products according to their different boiling points.

The high cylindrical still is set in brickwork, so that the hot gases from a fire underneath (but out of direct contact with the still) can circulate round the still walls. The fire is used for heating the superheated pipes, the hot gases not being passed through the flues surrounding the still until they have traversed the superheating chamber. The superheated steam

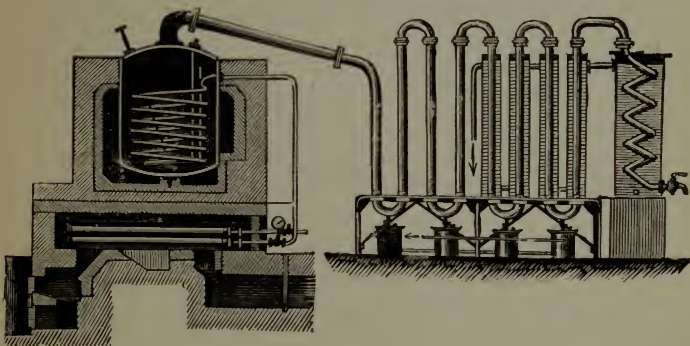

FIG. 1.

traverses a coiled pipe mounted inside the still and discharging near the hood of the latter. It is also advisable to have a circular, perforated steam coil in the bottom of the still, so that superheated steam can be forced through the mass of melted resin as well.

The distillation products traverse a system of condensing U-tubes, the bottom connections of which are fitted with draw-off tubes for the condensed distillates. The least volatile products condense in the tubes nearest the still, whilst the lighter distillates are condensed in the water-cooled tubes farther away, and the lightest of all in the condensing coil,

leaving the gaseous products alone to escape from the latter. These gases being combustible, are utilised by burning them under the boiler.

In order to reduce the waste of material to a minimum in the dry distillation of resin, it is advisable to only gradually raise the temperature of the molten resin, and not until the amount of distillate passing over is found to have become very small.

COALTAR OIL

The tar obtained as a by-product in the distillation of coal for gas-making furnishes, on distillation, a still larger series of products than resin; and several of these substances are used as ingredients of lubricants. This tar furnishes highly volatile hydrocarbons, known as benzol and used as solvents, together with a fairly large amount of light tar oils (so-called naphtha), solid hydrocarbons (naphthalene), carbolic acid, and a good deal of asphaltic residue (tar asphalt). Of these, the light tar oils and the naphthalene are used for our purpose.

CHAPTER XVI

Lubricants of Fat and Resin Oil

Resin oil is miscible with solid and liquid fats in all proportions, and the products exhibit properties corresponding to those of the components of the mixture.

RESIN OIL AND TRAIN OIL LUBRICANT

Resin oil	100
Refined train oil	50

Since this mixture deposits a sediment after standing for some time, it is important that it should not be used as soon as made, but should be stored in vats or casks for a while.

SOLAR OIL LUBRICANT

Solar oil	30
Refined rape oil	20

This lubricating oil is particularly suitable for brass and bronze machine parts, as it does not corrode these metals to more than an inappreciable extent.

THICK OIL LUBRICANTS

	No. 1. *For Winter Use.*	No. 2. *For Summer Use.*
Tallow . . .	35	60
Resin oil . . .	10	8
Rape oil or olive oil .	65	40

PATENT RESIN OIL AXLE GREASE

This lubricant, which is of a special character, both in its composition and method of preparation, consists of a combination of the acids formed during the dry distillation of resin, with lime and the volatile oils (resin oil) also formed during that process.

To obtain a resin oil suitable for this purpose, all the liquid distillates passing over between 170° and 185° C. are collected separately, only the heavier fractions being regarded as resin oil, whilst the above-named lighter fractions are utilised direct as oil of turpentine.

The distillation of the resin is preferably conducted in an iron still resembling the retorts used in gasworks. For working on a small scale, the ordinary iron or copper stills may be used.

The primary ingredient for making axle grease of these tar oils is slaked lime. This is prepared by pouring water over quicklime until it ceases to take up any more. The lime soon begins to grow hot, cracks, swells up, and finally crumbles away into a delicate powder, namely, calcium hydrate, or slaked lime.

This product is stirred up with just sufficient water to form a fairly thick milky liquid, which is then strained through a very fine wire gauze sieve, in order to remove small stones, grains of sand, and other solid bodies accidentally present in the lime.

The vat into which the milk of lime is strained must be fitted with a number of tap holes at short vertical intervals. In proportion as the liquid in the vat clarifies it is drawn off, until finally there is nothing left but a very fine, white pulp of milk of lime.

Into this the resin oil is poured in the form of a stream no thicker than a quill, the lime being kept stirred all the while.

The mass soon thickens owing to the separation of water, whereupon the supply of resin oil is stopped, and the operation completed by stirring the mass until perfectly uniform.

The proportion of lime required varies, but 20–25 per cent. of the weight of the resin oil is usually sufficient.

The colour of this grease is pale to dark yellow, according to that of the resin oil used: it is partly transparent, and possesses several advantageous properties. When the grease is made on a large scale, the resin distilled on the premises, and the stirring effected by some cheap form of power, the price of the product works out so low that it is able to compete with any other form of grease.

The second advantage offered is that of general applicability. The grease may be used in summer and at fairly low winter temperatures, equally well, its consistency varying only slightly under changes of temperature. Its firmness renders the use of any special grease-holder unnecessary; and for ordinary waggons it is sufficient to smear the axles well with the grease to keep them effectually lubricated for a considerable time.

PARAFFIN OIL GREASE

Towards the close of the distillation of tar certain thick oils, known as paraffin oils, come over. These products are admirably suited for the preparation of lubricants for heavily loaded axles. These paraffin oils are easily mixed with fatty oils, all that is necessary being to heat the fatty oil (generally rape oil) and the paraffin oil separately, and then mix them by continued stirring. When these greases are to be used on machines that are exposed to changes of temperature, it must be borne in mind that the consistency of the grease increases considerably at low temperatures, and therefore the proportion of paraffin oil must be greatly reduced for winter use. The two following recipes are for summer and winter grease respectively.

PARAFFIN OIL GREASES

	Summer Grease.	Winter Grease.
Paraffin oil . .	10	6
Refined rape oil .	90	94

It is self-evident that these recipes can also be modified to furnish greases suitable for medium temperatures, *i.e.* spring and autumn use, all that is necessary being to increase or diminish the proportion of rape oil accordingly.

These paraffin oil greases, which have hitherto been insufficiently appreciated, form excellent lubricants both for axles and machinery, and can be produced cheaply wherever paraffin oil is easily obtainable. In addition to perfect lubrication, they have the advantage of not corroding the machine parts.

PARAFFIN AND VASELINE GREASE

Pure white paraffin and vaseline can be mixed in any proportion by melting them together, and furnish greases ranging in consistency from that of soft butter to thick salve, by varying the quantities. Being perfectly free from acid, they are admirably suited for fine machinery and axles, whether running at high or low speed.

CHAPTER XVII

Neatsfoot Oil

NEATSFOOT oil occupies the highest rank among lubricating oils, and is the best for lubricating fine machinery, especially fine machine tools, sewing machines, cycles, small, quick-running axles, etc.

It would be equally useful for lubricating larger machines, such as high-speed turbines, dynamos, etc., but that its high price is an objection. For makers of fine lubricants, that are sometimes vendible at a very high profit, the preparation of neatsfoot oil is strongly recommended; for this oil can be obtained in a very high state of purity when treated in small quantities, and then forms an unsurpassed lubricant for the finest machinery.

Neatsfoot oil owes its excellent properties to the circumstance that it will keep for years in contact with the air without turning rancid or losing its fluidity. This latter property it retains almost unchanged, even at very low temperatures.

The method of producing neatsfoot oil is as follows: The fresh hoofs of oxen, calves, or pigs are boiled with water in a pan for a quarter of an hour, the temperature being then reduced so far that the liquid is no longer in ebullition. The fat collecting as an oily layer on the surface of the hot water is constantly skimmed off with a flat ladle and transferred to a deep, narrow vessel. The residue in the boiling pan—the hoofs deprived of their fat—is sold to the glue manufacturer.

After standing for some time the neatsfoot oil collects on

the surface of the vessel as a perfectly clear layer of golden yellow oil. It is then poured off from the oil into small white glass bottles, which are tightly corked and exposed to the influence of direct sunlight, which very soon bleaches the oil water-white. According to experiments performed by the author, the bleaching is accelerated by placing a sheet of violet glass in front of the bottles, the violet rays having the most powerful chemical action.

A large number of the lubricating oils sold under various names for oiling sewing machines, clocks, and other fine machinery, frequently in very small bottles at a hundred times their real value, are nothing more than neatsfoot oil, prepared, carefully refined, and bleached in the foregoing manner.

It may be mentioned here that neatsfoot oil desired to give the finest product should be exposed to a low winter temperature, and, whilst still cold, strained through a fine cloth in order to separate the liquid portion from that which has solidified.

CHAPTER XVIII

Bone Fat

IN large towns where there is always a very considerable quantity of *fresh* bones available, the practice of working these up in the preparation of lubricants is highly advisable, since they furnish a product almost equal to neatsfoot oil, and at a very low price indeed. The recovery of fat from the bones does not spoil them for the purposes of the makers of glue or bone black.

Fresh bone fat consists of several individual fats, two of which can be readily differentiated, namely, a fat that solidifies somewhat easily, and one that remains liquid even under the greatest cold. The latter is the constituent we know as bone oil, and is the more important for the production of lubricants.

The author has found the following to be the best method of preparing pure bone fat. The fresh bones are placed in a pan and covered with water, which is then raised to the boil very slowly, boiling being continued for several hours and the mass afterwards left to cool. At the end of five or six hours the bone fat will have collected on the surface, and can be skimmed off, so long as it remains fluid, into a lead-lined wooden vat.

The crude fat from perfectly fresh bones is entirely free from any kind of smell; but only small quantities of this grade are obtainable, since, even in large towns, the bones available have often undergone alteration to such an extent

that the organic matter is partly decomposed. It is therefore advisable to put the fat through a refining process, to destroy both the malodorous substances and the yellow-brown colouring matter mixed with the fat.

The best purifying agent is nitro-hydrochloric acid or aqua regia, prepared by shaking up a mixture of 1 part by volume of white nitric acid and 4 parts of crude hydrochloric acid in a glass vessel—any other material would be strongly corroded—until the mixture has assumed a reddish yellow colour and gives off a penetrating smell of chlorine.[1] When these two acids are brought into contact, chlorine is soon liberated; and this substance has a powerfully destructive action on colouring matters and odoriferous substances.

No larger quantity of aqua regia should be prepared at a time than can be used within the next few days, since the chlorine escapes during longer storage and the activity of the reagent is diminished.

To bleach the crude bone fat with this reagent it is treated with 1–1½ per cent. of the latter in a lead-lined wooden vat, the two being well mixed by prolonged stirring. The quantity of aqua regia required depends on the colour and smell of the fat; the darker and more evil smelling the latter, the more of the acid mixture necessary. The fat and acid are left in contact for several hours, to make the chemical reaction as complete as possible.

When bleaching is completed, warm water is run in and the acid is carefully drawn off through a taphole at the bottom of the vat, without allowing any of the fat to escape along with it. The fat is again mixed with warm water, which is stirred up and drawn off; and this washing must be

[1] This glass vessel should be unstoppered and placed in a dark place where there is a current of air, *e.g.* in a box out of doors. It must be left unstoppered in order that the chlorine gas liberated may escape unchecked.

repeated until the last trace of acid has been removed. It should here be mentioned that, at first, the lead plates lining the vat are strongly attacked by the acid, and become coated with a white film, which, however, must not be removed. It consists of lead chloride, and, once formed, protects the underlying lead, like a varnish, from any further action of the acid.

Properly bleached fat from fresh bones is nearly colourless and inodorous, free from acid, melts readily, and forms a lubricant closely resembling pure bone oil in quality.

Usually, however, the bones available for making bone fat are stale, the organic matter being already in an advanced stage of putrefaction, and the fat also more or less decomposed. To successfully use such bones for the preparation of lubricating oils, the method described above must be somewhat modified.

The bones are boiled, as already described, with water, and furnish a stinking, brown, smeary fat, partly consisting of free oleic acid. This fat is ladled into wooden vats, where it is left to stand for several days. As it slowly cools, a granular, greyish white fat separates out, leaving an evil-smelling brown oil floating on the surface. The solid portion is used for making common soaps, whilst the liquid portion serves for the preparation of lubricants.

This liquid portion is treated with nitro-hydrochloric acid as already described, and is thereby bleached and purified. The older the bones, the greater the amount of acid necessary to remove the smell and colour of the oil. The exact quantity can only be determined by direct experiment in each case; but in any event great care must be exercised in using larger quantities, and after the first 1 per cent. of acid is in, any further addition should not exceed $\frac{1}{4}$ per cent. at a time.

The bleached and deodorised bone fat still contains a large proportion of free oleic acid formed by the decomposition of

the fat during the storage of the bones; and this admixture must be removed before the fat can be used as a lubricant.

This is best effected by treating it with about 10 per cent. of caustic lime, slaked just before use, the resulting milk of lime being stirred up with the fat and left to settle. In this manner the oleic acid is entirely removed by the lime.

According to special experiments performed by the author, the oleic can also be eliminated by means of litharge, especially when the fat has been previously warmed. The resulting lead oleate remains mixed with the fat, and converts the latter into a mass with the consistency of strong salve, highly suitable for axle grease.

Very good lubricants can be prepared by mixing bone fat with rape oil, and as the bones can be utilised for making glue and bone black, these lubricants are very cheap to produce.

BONE FAT GREASES

	1. *For Summer Use.*	2. *For Winter Use.*
Bone fat . . .	60	40
Raw rape oil . .	40	60

TRAIN OIL GREASES

The cheap and abundant train oil obtained from the blubber of various kinds of whale, dolphin and seal is estimated below its true merits as a lubricant; but in America, where its value is recognised, it is largely used for this purpose, many railways employing it for greasing locomotives and axles, to the exclusion of all other greases.

To convert the dark-coloured and generally malodorous crude train oil into a good lubricant, it should be exposed to a low temperature, which, as already mentioned, causes it to deposit a considerable quantity of solid fat, after which

it is treated with litharge to eliminate the free oleic acid present.

For this purpose the litharge is ground very fine, and is put through a mill along with a small quantity of the train oil, just as in making paint, so as to produce a thick, viscous mass. This is then thinned down with a further quantity of train oil, and incorporated with the bulk by efficient stirring.

The liquid is next left to stand for a short time, whereupon the excess of litharge settles down as fine sludge, whilst the newly formed compound of lead and oleic acid remains in the liquid, and increases its viscosity.

CHAPTER XIX

Lubricants for Special Purposes

GREASES FOR QUICK-RUNNING AXLES

1	Soap	1
	Rape oil	1
	Water	5
	Powdered talc	2
2.	Brown ozokerite	10
	Petroleum	4

In the case of No. 1 the ingredients are mixed by boiling and stirring them together, whilst for No. 2, melting together is sufficient.

PISTON-ROD GREASE

Paraffin	1
Powdered talc	4

are stirred together whilst hot, wicks are then dipped in the mixture, and are afterwards pressed into position in the piston-rod gland. This lubricant will grease a piston rod for 8–14 days with one application.

COG-WHEEL GREASE

Any convenient buttery lubricant is melted and stirred up with 5 per cent. by weight of finely ground and levigated powdered glass. In a short time this lubricant polishes the cog-wheel teeth perfectly smooth and even.

DRIVING-BELT GREASE

Linseed oil	45
Litharge	20
Water	20

These three substances are boiled together until the mass has assumed the consistency of plaster, and is thinned to about the same degree of fluidity as varnish, by adding oil of turpentine in the warm.

BELTING GREASE

Linseed oil	9
Litharge	4

boiled together, along with water, until a sample sets to the consistency of plaster, the mixture being then thinned down with oil of turpentine while still warm.

CAOUTCHOUC GREASE FOR DRIVING BELTS

I. Five hundred parts by weight of caoutchouc are dissolved in an equal weight of oil of turpentine at 122° F., and mixed with 500 parts of colophony and 500 of yellow wax.

II. One and a half parts of fish oil are melted with 500 parts of tallow, and the mixture is stirred with the solution No. 1 until the mass sets. The grease is laid on the belts with a brush, in the vicinity of a hot stove.

BELGIAN CART GREASE

Lime slaked to powder	100
Tar oil	300
Paraffin oil	800
Resin oil	300
Strong lye	12

The dry-slaked lime and the lye are placed in a pan, in which they are stirred with the resin oil until the whole mass is white. This being gently warmed, the tar oil is stirred in, followed by the paraffin oil, 800 parts of powdered soapstone being finally added. The finished composition is stirred until homogeneous.

Under the same name as the above, a number of different preparations have been placed on the market. Their chief constituents, however, are those just given, and the colour (red, brown, blue, or black) is about the only point of difference. The red colour is imparted by colcothar (*caput mortuum*), brown by lamp black, blue by ultramarine or Prussian blue, and black by a larger proportion of lamp black. In some recipes powdered soapstone is replaced by ground heavy spar, which, however, is objectionable, being a very hard, crystalline substance, and therefore capable of abrading and wearing out the machine parts it is used to lubricate.

ENGLISH PATENT AXLE GREASE

This term is applied to a whole series of compositions, consisting mainly of a kind of lime soap with variable proportions of added resin oil and coaltar oil, the product being coloured yellow, brown, blue, etc.

The lime soap, or "basis," is usually prepared by stirring and heating train oil with slaked lime until the two have united to a thick liquid. The general proportion of the ingredients is 7 parts of oil to 5 of lime; but the exact amount of the latter varies according to the nature of the train oil. The correct amount is reached when the product in the pan has a syrupy consistency after being boiled for about an hour.

These patent greases are usually prepared on a large scale, and the ingredients are mixed in large vats fitted with stirrers

worked by steam. Stirring must be continued until a sample taken from the mixer sets to a homogeneous mass.

WHITE PATENT GREASE

Basis	100
Resin oil	100

BLUE PATENT GREASE

Basis	100
Resin oil	125
Coaltar oil	15–25

according to the consistency desired. The grease is coloured blue with ultramarine or Prussian blue. The brown and black greases are made in the same way, the only difference between any of the series being the quantity of resin oil and the kind of colouring matter used.

SOAP AND MINERAL OIL LUBRICANTS

A special group of lubricants is formed by those compounded of soap and mineral oils. When petroleum is heated with 2–3 per cent. of soap to the boiling point of water for a short time, with continued stirring, the whole sets to a buttery mass. A similar result is obtained by boiling resin-and-lime soap with resin oil in a corresponding manner.

The resin-and-lime soap is prepared by treating quicklime with sufficient water to slake it to powder, which is then thinned down with water to a milky liquid and heated to boiling. Resin, to the extent of about 1½ times the weight of the lime, is stirred into the boiling liquid, and the whole is left to cool, whereupon the supernatant liquid is poured off and the soap dried.

To make the lubricant, resin oil or heavy tar oil is heated and mixed with about 2–5 per cent. of the dry lime soap, the whole being boiled and sampled, the sample cooled

quickly and examined. If too little of the lime soap has been taken the sample will be too soft, and more soap must be added; but if the sample prove too hard, then the proper consistency is obtained by adding resin oil or mineral oil. Since the various resin oils and mineral oils behave differently in this respect, no exact recipes can be given, and the amount of lime soap required for a given quantity of resin oil must be determined by trial in each case.

COLL'S PATENT LUBRICATING OIL

This preparation consists of resin oil that has been boiled along with a quantity of slaked lime insufficient to produce saponification. Hence the composition is really a resin oil and lime soap mixed with an excess of resin oil. Being perfectly free from acid, it can be recommended as a lubricant.

AMERICAN MACHINE OILS AND SOLID GREASES

A number of these products have been found, on careful examination, to possess the following composition:

I.	Oleic acid	90
	Petroleum	10
II.	Oleic acid	100
	Glycerine	50
III.	Oleic acid	100
	Guaiacum oil	20
IV.	Glycerine	100
	Petroleum	10
V.	Glycerine	100
	Olive oil	50
VI.	Gambier fat	100
	Coal tar	30

TURBINE OILS

	I.	II.	III.	IV.
Yellow resin oil .	200	200	40	40
Blue resin oil .	...	33	...	...
Olive oil . .	1	...	40	...
Rape oil . .	...	33	...	...
Olein . .	...	...	60	...
Cottonseed oil .	...	...	...	30
Paraffin oil .	...	...	...	30

These oils are suitable for all quick-running shafts or axles under light loads.

ROPE GREASE FOR WIRE ROPEWAYS

Tar	100
Brewer's pitch	100
Colophony	25
Train oil	10–25

are melted together and stirred until the mass is cold.

SCHUCKART'S PATENT BELTING GREASE

This fat, which is intended to prevent leather belts slipping on the pulleys, consists of castor oil containing an addition of up to 10 per cent. of tallow according to the temperature.

DRECHSLER'S PATENT GRAPHITE LUBRICATING POWDER

Finely powdered graphite is mixed to a paste with egg albumin, then heated to about 160° F. to coagulate the albumin, reduced to powder and used. This preparation is in nowise superior to graphite and tallow mixtures, but comes out much higher in price.

CHAPTER XX

Mineral Lubricating Oils

THE name "mineral lubricating oil" is applied to products of highly divergent origin; and they are obtained in very large quantities in the refining of crude petroleum and the distillation of coal tar. Since these oils are unsuitable for lighting purposes, owing to their dim, smoky flame when burned in lamps, but become more and more consistent as their density increases, they may, in view of this latter property, be regarded as true universal lubricants, since they can be prepared in all degrees of consistency from very thin to extremely viscous oil. They possess, namely, the property of absorbing considerable quantities of paraffin, and of becoming thicker in proportion to the amount taken up.

Attention is specially directed to these oils because they are easily prepared, and can be produced in large quantities in petroleum refineries and tar distilleries. Those interested in lubricants will recall the great flourish with which they were first placed on the market (from America); and, indeed, their good qualities entitle them to recommendation.

Owing to their freedom from acids and on account of their cheapness, the mineral oils are admirably adapted for the preparation of lubricants. In making a choice, selection should fall on the heaviest oils, which on account of their high density are of little or no use for burning.

In America the method adopted is to subject the crude petroleum to fractional distillation, and as soon as the distillate has reached a certain density, the fractions subsequently passing

over are collected and sold as lubricating oil. Properly prepared lubricating oils of this kind are almost entirely inodorous and free from colour. They may be used either alone—as fine machine oil—or mixed with resin and paraffin.

VULCAN OIL

is one of the mineral lubricating oils, and is obtained in the distillation of Virginia petroleum. It has the sp. gr. 0·870–0·890, and is purified by treatment with sulphuric acid.

GLOBE OIL, ETC.

The mineral lubricating oils largely imported from America under the names Globe oil, Eagle oil, Phœnix oil, etc., have properties closely resembling those of Vulcan oil, and, like that oil, are obtained by the fractional distillation of crude petroleum.

THICK MINERAL LUBRICATING OILS (GREASES)

These oils are prepared by boiling together milk of lime, some vegetable oil and a mineral oil, until a homogeneous salve-like mass is obtained. A lime soap is formed, which dissolves in the oils; and the larger the quantity of this soap the higher the melting point of the grease. On account of this high melting point and the viscosity of the mass when melted, these greases are specially suitable for high pressure steam engines. All the preparations known as Patrick's, Reisert's, Tovote's greases, etc., belong to this class.

RECIPES FOR MINERAL OIL GREASES

	I.	II.
Mineral oil	100	100
Linseed oil	30	30
Ozokerite oil	20	20
Lime	9	5
Magnesia	...	4

	III.	IV.
Mineral oil	100	100
Linseed oil	25	...
Ozokerite oil	35	...
Rape oil	...	40
Cocoanut oil	...	10
Lime	10	10

	V.	VI.
Mineral oil	100	100
Resin oil	100	...
Rape oil	50	30
Linseed oil	75	...
Ozokerite oil	...	20
Lime	25	15

VASELINE

Under this name, or as paravaseline, are placed on the market (in the first place from America) lubricants that admirably fulfil their purpose, since, being free from acids, they do not corrode the metallic parts of the machinery. They consist exclusively of the by-products obtained in the distillation of Pennsylvania crude petroleum. In this process there remain as residuum in the stills, semi-solid masses consisting of various crystalline and liquid hydrocarbons of very high boiling point, and capable of direct utilisation as lubricants.

PARAVASELINE

Lubricants of greater fluidity can be easily obtained by mixing vaseline with petroleum; and conversely, thicker lubricants can be prepared by the addition of crude paraffin or ozokerite. Paravaseline, for instance, is compounded of vaseline and paraffin. Generally these lubricants are coloured by means of cheap colouring matters: colcothar for red, umber for brown, and so on.

SOAP AND VASELINE GREASES

Crude vaseline mixed with ordinary or resin soap furnishes a very good railway grease, green to brown in colour. Six to 8 parts of crude vaseline are melted along with 1 part of tallow and 1 of colophony, $1\frac{1}{2}$ parts of soda lye (20° Bé.) being poured in as a thin stream, and the whole stirred continuously until the mass begins to get viscous, whereupon it is poured into cans, drums, etc., for sending out.

LANOLIN LUBRICANT

In scouring sheep wool, a product known as wool fat, wool yolk, or suint, is obtained, and this in turn furnishes lanolin or wool oil. Lanolin, when quite pure, is a soft mass of fatty character, but is not a fat, and therefore never turns rancid, so that it forms an excellent lubricant. It is particularly adapted for axle grease, only the crude lanolin being, of course, used for this purpose. The method of preparation adopted consists in heating some vegetable oil with milk of lime and crude vaseline, until a homogeneous mass is obtained, melted lanolin being then added in a thin stream and stirred with the rest until the product has attained the consistency of soft salve. The mass may be stiffened to any desired extent by the addition of ground soapstone, clay, or infusorial earth.

LANOLIN AXLE GREASES

	I.	II.
Rape oil	10	...
Linseed oil	...	10
Quicklime	5	5
Water	20	20
Crude vaseline	500	600
Crude lanolin	40	40

with clay, soapstone, or infusorial earth in the proportion of 10–25 per cent. of the whole mass.

CHAPTER XXI

CLOCKMAKERS' AND SEWING MACHINE OILS

LUBRICANTS for clocks and delicately constructed machinery in general are usually prepared from very carefully refined rape oil, or preferably fine olive oil. To remove the final traces of acid from the oil, it is shaken up with 1 per cent. by weight of caustic soda, this being repeated several times daily for two or three days. A large volume of water is then added, and the supernatant oil, which is now quite free from acid, is poured off.

It, however, still contains colouring matters and certain other constituents inimical to lubrication: and to remove these the oil is shaken up with strong alcohol, which dissolves them out.

For this purpose, 10 parts by volume of the oil are placed in a clear glass bottle holding about one-third as much again, along with 2 parts of 90 per cent. alcohol. The bottle is next well corked, and shaken up so as to thoroughly mix the oil and spirit. The bottle is set out in the sun, and shaking repeated several times a day. At the end of about three weeks—though in bright summer weather, ten to fourteen days often suffice—the oil will be water-white, the supernatant layer of spirit having assumed a strong yellow tinge through the colouring matter absorbed from the oil.

The purified oil is syphoned off and filled at once into small tightly corked glass bottles, which should be kept in a cool dark place. The spirit can be recovered, by careful

distillation, in a perfectly colourless condition and used over again.

According to the author's experiments, the best oil for clocks is finest olive oil or freshly pressed oil of sweet almonds, bleached with spirit as above, and used either alone or mixed together in equal parts.

FATTY OIL FOR CLOCKS

For oiling clocks the cost of the oil is a relatively unimportant consideration, experience shewing that clockmakers and all other makers of the more delicate kinds of machinery will readily pay very high prices for a lubricating oil that will meet their requirements. Lubricants for this purpose must, first of all, have no chemical action on metals, and must not thicken or "gum" in course of time.

As the result of many experiments, the author is convinced that there are only two substances really suitable for the purpose in question, namely, olive oil and pure bone oil.

OLIVE OIL FOR CLOCKMAKERS' USE

To prepare this lubricant an olive oil must be taken that has been refined by the sulphuric acid method already described, and afterwards shaken up with about 2 per cent. of weak lye to ensure the complete elimination of the final traces of free acid. The oil and lye are left in contact for several days after a thorough shaking, the oil floating on the surface being then drawn off and bleached with spirit as described above.

Like all other fine lubricating oils, the olive oil so treated must be filled into small bottles, which are then tightly corked and stored with care.

BONE OIL FOR CLOCKMAKERS' USE

Bone oil is the best of all lubricants for clocks and other delicate machinery. It is especially valuable for turret clocks,

owing to its valuable property of remaining perfectly fluid, even at very low temperatures, whilst all other oils set, or at least thicken considerably at a very few degrees below the freezing point of water.

To refine bone oil for the purpose in question, the oil after a preliminary refining process, is exposed to a low temperature, approaching the freezing point of water, and not higher than 35·5° F.

At the end of several hours, under these conditions, the bone oil will have deposited a solid mass of fat at the bottom of the vessel, and the supernatant liquid portion may then be poured off. This method of refining bone oil is easily performed in winter; but in summer the operation has to be somewhat modified. With this object, the oil is placed in a vessel, which is then immersed in cold spring water containing lumps of ice, fresh portions of the latter being added in order to keep the temperature near the freezing point for several hours. The vessel containing the oil may then be taken out and the oil poured away from the solid fat.

A still finer product, constituting the best of all lubricating oils, is obtained by treating bone oil in the following manner: The oil to be refined is placed in a flask large enough to hold three times the quantity. Water-white benzol is poured on to the oil in small quantities at a time, and after closing the flask the contents are shaken up until the benzol has entirely disappeared. By repeating this operation several times a complete solution of the fat in benzol will be obtained, this being shewn by the fact that the contents of the flask will no longer separate into two layers when left to stand.

The flask is next exposed to a low temperature, as described above, for several hours, and will deposit a solid fat, the quantity of which is larger in proportion as the cooling temperature is lower. The flask is then shaken up and the contents poured

into a second flask, through a funnel containing a plug of cottonwool, which retains the solid matter and allows the liquid portion to pass into the second flask. The resulting clear solution of bone oil in benzol is afterwards placed in a small retort, connected with a properly cooled receiver and heated by means of a leaden water bath. The benzol distils over, leaving the refined bone oil in the retort, whilst the benzol collected in the receiver can be used over again.

A suitable distilling apparatus for this purpose in shewn in Fig. 2. Cold water is run from the vessel D, through the tube h,

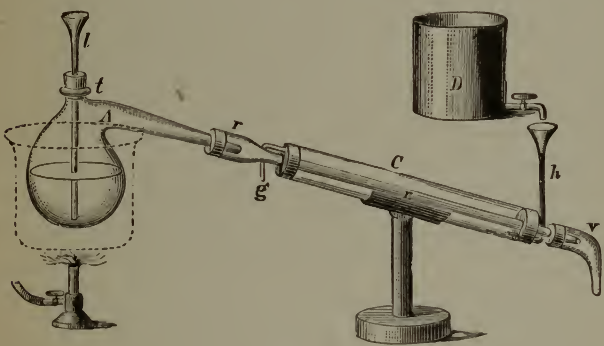

FIG. 2.

into the outer tube C of the condenser, thus cooling the inner tube r, and condensing the benzol passing over from the still A, so that it drops into the receiver v, whilst the cooling water escapes through g at the upper end of the condenser. Fresh quantities of the benzol solution of bone oil can be introduced into the still A, through the funnel t l. The latter is then transferred to another flask, which is placed in a warm room, whereupon the solid fat on the cottonwool filter melts and runs down into the flask. This portion furnishes an excellent lubricating oil for fine machines, such as sewing machines, that are not exposed to any low temperatures.

FINE MACHINE OIL

Ten parts of rape oil are warmed along with 5 parts of 90 per cent. spirit until the latter begins to boil, the whole being kept stirred. When ebullition of the spirit sets in, the heating is discontinued and the liquid is poured into a large flask of clear glass, in which it is exposed to sunlight until thoroughly bleached.

MINERAL OIL FOR CLOCKMAKERS' USE

The mineral oil for clockmakers' use is a specially refined heavy tar oil. One hundred parts of ordinary heavy tar oil are treated with 2 parts of bleaching powder, well stirred in, and followed by 3 parts of crude hydrochloric acid. The mixture must then be vigorously stirred, and set aside for six hours. At the end of this time the oil is poured off from the watery liquid, and repeatedly shaken up with 5 parts of caustic soda lye each time. Finally, the refined oil is filtered through grey blotting paper.

CAOUTCHOUC LUBRICANT FOR SEWING MACHINES

Olive oil	50
Almond oil	50
Rape oil	50
Caoutchouc	2
Carbon disulphide	4

The caoutchouc is cut into very small pieces and placed in a tightly closed bottle to swell up in the carbon disulphide. When this is done it is quickly transferred into a flask containing the oils, this flask being placed in a heated water bath. Whilst the water is being raised to boiling point the mixture is kept stirred. The swelling of the caoutchouc takes a week, the pieces, which should not fill the bottle more than

a quarter full, being suffused with just sufficient carbon disulphide to cover them.

Care must be taken in heating the mixture of oils and swollen caoutchouc, to avoid inhaling the injurious vapours of carbon disulphide that are given off; and no open light or flame must be allowed in the room in which the operation is performed, these vapours being highly inflammable, and even explosive when ignited in admixture with air.

MINERAL OIL FOR SEWING MACHINES

Petroleum	100
Water	10
Bleaching powder	1

The bleaching powder is dissolved in the water, the solution being filtered and well shaken up with the petroleum. At the end of two hours the oil will have separated from the bleaching powder solution, and is then shaken up with an aqueous solution of caustic potash, from which it is afterwards separated by distillation.

SEWING MACHINE AND CLOCKMAKERS' OIL

A mixture of—

Olive oil	3
Almond oil	2
Rape oil	1

is treated with alcohol as already described. This mixed lubricant is fairly fluid, and is therefore admirably suited for oiling very fine machine parts.

CHAPTER XXII

The Application of Lubricants to Machinery

In practice, the question is not merely to employ the best lubricants, but also to use them in the most economical manner possible. The consumption of a small percentage more or less of oil is by no means a matter of indifference to a manufacturer with a large number of machines in constant work, since the increased amount resulting from defective application totals up to a considerable extra outlay per annum in a large establishment.

To obviate this, the first point is to select the most suitable lubricant for the machinery in question, and then apply it by the aid of appropriate lubricators.

These appliances are now made in various types, according to the kind of lubricant used and the construction of the machinery. Thus, for instance, no special appliance is needed for ordinary carts, the wheels being merely taken off and replaced after the grease has been smeared on the axles; whereas vehicles of superior type, such as carriages, are fitted with oil holders, which are kept filled and lubricate the axles continuously. This continuity of lubrication is indispensable in the case of axles that are run at high speed, such as railway waggons and locomotives; and for axles of this type special grease boxes are used, filled with grease, and deliver it uninterruptedly to the axles through a narrow orifice for that purpose. The construction of these grease boxes varies according to the class of solid or liquid lubricant used, and all more or less fulfil their purpose of

supplying the axles with just sufficient lubricant without allowing any to run to waste.

The large number of different types of grease boxes designed and used affords sufficient proof of the considerable difficulties attending their construction. On this point the interested reader is referred to the technical literature of the subject, the construction of these appliances falling within the domain of mechanical, rather than chemical, technology.

We will, however, give a brief description of the principal

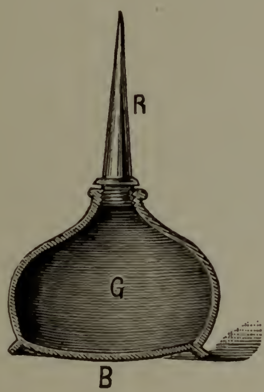

FIG. 3.

lubricators designed for use with fluid lubricants on different classes of machinery.

THE FLEXIBLE OIL CAN

This small vessel, which does excellent service, and is illustrated in Fig. 3, consists of a metal case G, with a conical screw nozzle R, terminating in a small orifice. The bottom B of the can is convex, and is made of flexible sheet metal.

When this can is filled about two-thirds full of oil and is turned upside down, the application of pressure to the bottom B with the thumb, compresses the air inside and causes it to press on

the oil, which is now occupying the tube R, thus forcing a drop out of the nozzle. The number of drops expressed in this way depends on the amount of pressure exerted on the can bottom.

On turning the can upright again, more air enters from the outside through the nozzle, and each time the bottom is pressed, any convenient number of drops of oil can be forced out.

This class of can is very largely used for oiling sewing machines, embroidering machines, small planing and drilling machines, turret clocks, and in fact for all kinds of small delicate machinery that do not run at such high speed as to require the use of continuous lubricators.

Although the practice would increase the cost of these cans, it is recommended that they should be lightly plated with silver on the inside, instead of being made of ordinary sheet brass or zinc. This slight addition to the cost would be more than repaid by the certainty that good lubricating oils, such as bone oil, would keep (as the author has proved by his own experience) perfectly colourless and fluid for many months, whereas in brass cans, they soon acquire a greenish tinge and become thick. This is due to the metal being corroded in presence of air, the copper combining with the fatty acids of the oil and furnishing a compound which turns the latter green and thick.

THE AEROSTATIC OIL CAN

For large machinery, such as vertical and marine engines, boring machines, spinning and weaving machinery, etc., the author's experience goes to show that there is no better lubricator than the aerostatic oiler, which unites in itself a number of excellent qualities. Like the flexible can, this oiler is only suitable for fluid lubricants.

As shown in Fig. 4, this can consists of an elongated body G,

on which are soldered a long spout R, tapering to a fine nozzle, and a handle H. The form and length of the spout vary according to requirements, but in all cases it must be long enough to enable the oiler to place the can in position for oiling without getting his hand in danger from the running machinery.

At the highest part of the dome on the can body G is an orifice closed by a metal screw cap, which is dished at the top and is perforated by a fine bore.

The can is filled through O, after the screw cap has been

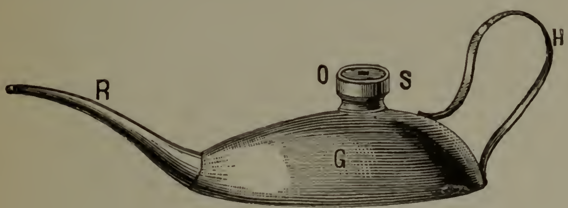

FIG. 4.

removed, the latter being then screwed on again. In use, the can is held by the handle, and the thumb is applied to the small opening in the screw cap, in which case only a single drop of oil is discharged when the can is tilted, the backward pressure of the external air on the liquid preventing it from running out more freely.

On removing the thumb from the cap, air enters the can through the bore, and the one-sided pressure being removed a stream of oil flows from the nozzle of the can. In this way the outflow can be regulated from a single drop to a continuous stream, or stopped altogether. The manipulation of this can is learned in a moment, so to speak, as soon as it is taken in the hand; and if the user employs sufficient care, not a single drop of oil need be wasted.

THE OIL CUP

For large shafts or axles the oil cup (Fig. 5) is used. In its simple form this cup consists of a small vessel G, which is mounted on the bearing of the shaft A, and is closed by a tight-fitting hinged cover, to keep out dust. A small conical tube R in the bottom of the cup allows the oil to flow down to the shaft, through the bearing.

The oiler fills the cup full of oil (preferably from an aerostatic can), and knows from experience how long this quantity will last. It is important to make the cup G rather shallow, and the tube R narrow, since otherwise the column of oil would be

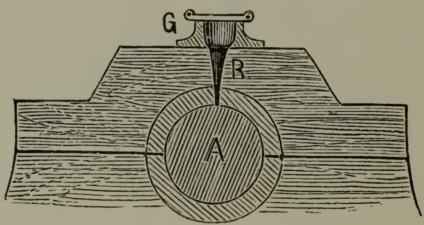

FIG. 5.

too high and exert an excessive pressure, thus causing a larger flow of oil out of the cup than is necessary for lubrication.

Some machine parts are constantly in motion, and therefore need continuous lubrication, whilst their inaccessibility precludes oiling by hand without stopping the machine. Devices are, however, provided for enabling this operation to be performed in a continuous manner while the machine is running. One of these is shown in Fig. 6, and is particularly recommended on account of its simple construction and high efficiency.

The drawing represents a ring R, running on a disc mounted on the shaft A, and in contact with the ring all round. Hence the surfaces in contact between the parts R and S must be

lubricated. Now, an ordinary oiling cup would throw the oil about, owing to the continuous movement of R: so to prevent this, a movable oiler is employed. This consists of a glass bulb G, which is screwed on to the ring R by means of a metallic mount. The mount carries an upwardly evased cone valve V, fitted with the stem S, whilst a narrow bore B leads to the contact surface between the ring and the disc.

To fill the oil bulb G it is unscrewed and inverted. The

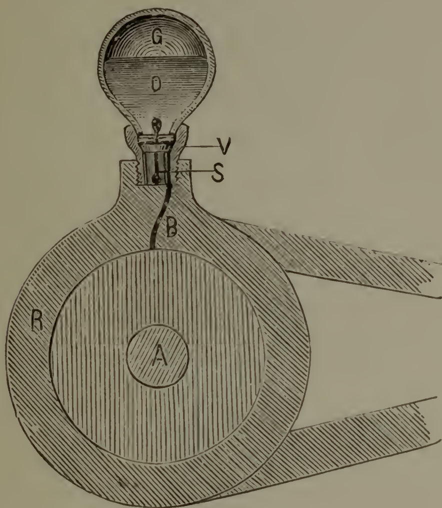

FIG. 6.

valve V is then closed by pulling at the stem S, the bulb is turned the right way up (no oil escaping), and is then screwed back on to the ring. The stem S is made long enough to raise the valve a little when the bulb is screwed home. The oil flows through the small orifice thus provided, and keeps the ring R supplied with oil until the contents of the bulb are exhausted. From time to time a bubble of air forces its way into the bulb, to replace the removed oil.

There are also a number of more or less appropriately con-

structed lubricating appliances, working automatically, for oiling moving parts of machinery. It being highly desirable to learn what quantity of oil is consumed under different circumstances, we will now describe an apparatus well adapted for this purpose (Fig. 7). From its mode of action it may be styled a drop-cup

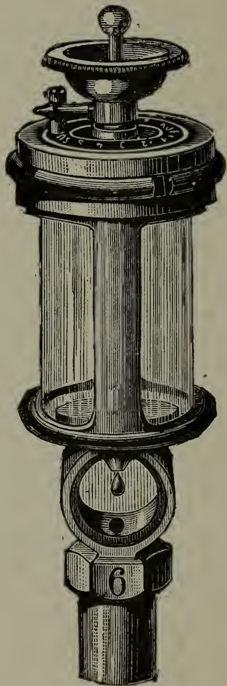

FIG. 7.

oiler. The vessel for holding the oil is made of glass, and the oil outlet at the bottom is enclosed between two panes of glass, so that the dropping of the oil can be observed. The delivery orifice may be controlled by a cone valve, which is attached to and turned along with a filling cup. The periphery of the metal mount surrounding the glass cylinder is graduated

into, say, ten parts of equal size; and a pointer attached to the regulating cone moves over this scale. When the pointer is opposite the zero mark, the oil outlet is closed; when it is opposite 9 on the scale, the maximum amount of oil is being delivered per unit time. The quantity of oil needed to fill the oiler being accurately known, once for all, the consumption of oil under certain given conditions can be easily calculated from

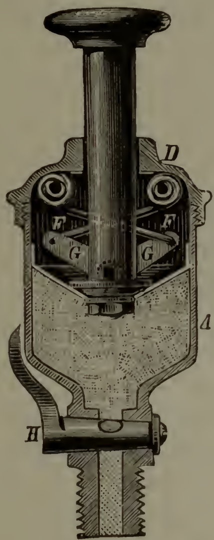

Fig. 8.

the time required to empty the cylinder of oil when the pointer is opposite different divisions on the scale.

For thick or buttery lubricants, greasers are used in which the lubricant is kept pressed against the part to be lubricated. In the Reisert spring greaser (Figs. 8 and 9) this pressure is exerted by spiral springs F, which press on the elbow piece G, and through this on the piston in position over the grease in the cup A. To maintain the piston in its highest position when the cup is quite full, there is a small peg on the piston

rod, and this peg holds the piston in place when turned round. To fill the cup, the cap is unscrewed, and the piston and its fittings removed. When the machinery stops running, the further outflow of grease is prevented by turning off a tap H underneath. Fig. 9 shows a similar greaser for large shafts,

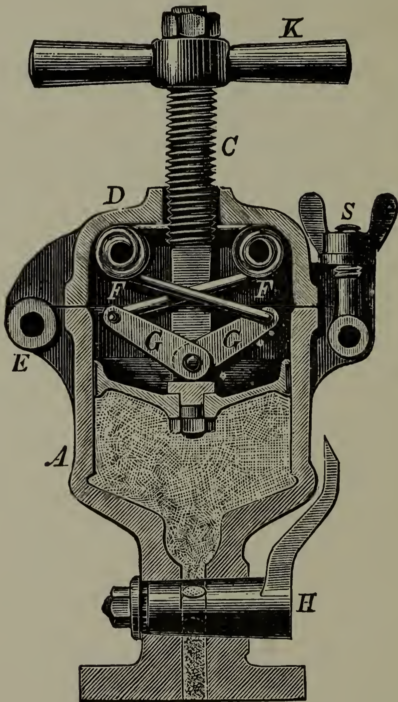

FIG. 9.

the only difference between this and the previous type being that the piston rod is threaded and traverses a nut in the cap, so that it can be screwed up and down to hold the piston back in filling the cup. The cup is refilled by loosening the screw S, and tilting the upper part of the greaser back, on the hinge E.

CHAPTER XXIII

Removing Thickened Grease and Oil

ALL who have anything to do with machinery are aware that a machine that has been out of use for some time cannot be started again until it has received a thorough cleaning. This is especially the case with regard to the lubricated parts, since the old grease or oil not only dries to a tough thick mass, but mixes with dust gathered from the air, and forms such a thick, hard crust, that in many cases it can only be scraped off with great difficulty.

To clean a machine that has fallen into this condition, it must first of all be taken to pieces, so far as possible, and the various parts dealt with separately. In carrying out this work, the kind of oil used must be borne in mind: whether solid or liquid fat, soapy or mineral oil lubricants.

If this information is not available, the nature of the old lubricant must be determined by an experiment. If a fatty lubricant has been used, it may be removed by treatment with caustic soda; and the same also applies to soapy lubricants. Mineral oils, however, cannot be got rid of by this treatment, and require a longer or shorter soaking in petroleum before they can be loosened. Machine parts that are covered with old fatty or soapy lubricants must be scrubbed with caustic lye until quite clean; after which they must be repeatedly washed with water, in order to remove the last traces of alkali, or they will soon rust. Finally, they should be rubbed dry with a soft cloth and smeared with vaseline, being then stored in a

place out of contact with dust, until the machine is put together again.

Metal parts covered with thickened grease that is soluble in petroleum are placed in a vessel of sufficient size, and petroleum is poured over them. After a time the lubricant will be either dissolved or else so far loosened that it can be removed without difficulty. They may be left until the adhering petroleum has evaporated, and are then ready for immediate use.

Both mineral oil and fatty lubricants can be removed much more quickly by the aid of benzol, and hence this solvent is particularly recommended for cleaning fine and delicate machine parts. Thus an old watch that has lain unused for a long time, so that the lubricating oil has become perfectly thick, can be cleaned ready for immediate wear, by soaking it in benzol for a few days and then leaving it to dry in the air for a few days. Sewing machines are best cleaned with petroleum or benzol. This operation is preferably performed by daylight, since both petroleum and benzol give off vapours that form an inflammable mixture with air, and one that may explode with violence if ignited by a flame or light.

CHAPTER XXIV

Cleaning Oil Rags and Cotton Waste

IN establishments where a large quantity of machinery has to be oiled and cleaned, it becomes profitable to recover the oil, etc., absorbed by the cleaning rags and cotton waste, and bring these materials into condition for use over again.

The best method of accomplishing this is based on the circumstance that all the bodies used as lubricants are soluble in petroleum ether (light petroleum spirit) or benzol, both of which are obtainable at low prices. The lubricants are dissolved in one of these solvents, and recovered by expelling the latter by evaporation, the solvents being also recovered for use over again.

For this purpose the greasy rags and waste are packed pretty closely in an iron drum, fitted with a draw-off tap at the bottom and a tight-fitting cover. Before fastening down the lid, a sufficient quantity of one of the above solvents is poured into the drum to cover the rags after the latter have taken up as much as they can absorb. The lid is then fastened down and the drum left for twelve hours, at the end of which time water is poured into a tube, about six feet long, projecting from the lid of the drum, and the draw-off tap at the bottom is opened. The dissolved lubricant runs out, being displaced by the water, more of which is added until clear water begins to flow from the bottom tap, shewing that the oil and solvent are all out.

The dissolved lubricant is then transferred to a still, which

is placed in a water bath, the latter being then heated to boiling point. The solvent boiling at a lower temperature, is completely evaporated, and can be recovered by means of a condenser, leaving the recovered lubricant in a fluid condition in the still.

It has been recommended by some that the greasy rags should be treated with solvent in a closed metal vessel, then quickly pressed, and the solution distilled. Experience shows, however, that even when the rags are pressed as quickly as possible, a good deal of the solvent is lost by evaporation, so that the recovery of the lubricant does not pay.

Rags soaked with fatty lubricants may also be cleaned by saponification. For this purpose they are placed in a pan, mixed with weak soda lye, and then boiled, one or two specimens being taken out from time to time to see whether all the fat is saponified. When this stage is reached all the rags are taken out, and the boiling is continued until a finished soap, of low quality, is obtained.

Cleaning rags or waste impregnated with mineral oils or paraffin grease cannot be cleaned with caustic soda, but must be treated with one or other of the above solvents.

STORING GREASY RAGS OR COTTON WASTE

A word of caution should be given on the subject of storing greasy cleaning rags or cotton waste. It has often been observed that rags soaked with fatty lubricants are liable to heat, when kept in heaps, the temperature rising to such an extent that they take fire and may cause immense damage.

The only explanation of this phenomenon is that the fat is exposed in such a large surface to the air that it readily oxidises, the heat thus liberated being sufficient to produce ignition. Consequently, strict orders should be given that all oily rags and cotton waste are to be put into special iron drums, with tight-fitting covers. In this way the risk of fire is

reduced to a minimum; and should it occur, the fire cannot spread, but will be extinguished for lack of air.

PURIFYING WASTE LUBRICANTS

In many machine parts that require copious lubrication, a good deal of oil runs away and is caught in collecting vessels placed underneath. This waste oil is generally contaminated with dust and microscopically small particles of metal, which

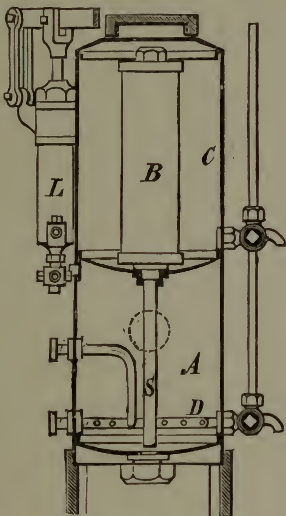

FIG. 10.

can be removed by filtration through two or three layers of thick blotting paper, the recovered oil being then suitable for use over again. Where small quantities are in question, the filtering apparatus need only be very simple; but for larger amounts, specially constructed appliances are necessary, especially in the case of viscous lubricants.

Of this type the apparatus of Heitmann & Co. (Fig. 10) is a good example. It consists of a cylinder divided into two com-

partments, A and C. The lower compartment A is charged with the oil to be filtered, and is fitted with a heating coil to increase the fluidity of the oil; whilst C contains the filter B, which is connected with A by the pipe S.

The oil in A is caused to flow through the pipe S, either by introducing steam into A or by exhausting the air from C; and in this manner the oil is filtered into C.

CHAPTER XXV

The Use of Lubricants

DIFFERENT purposes entail the use of different lubricants. True, one often hears of so-called "universal" lubricants; but these never succeed in doing all that is claimed for them: and indeed their name at once implies that their makers are ignorant of the nature of lubricants, for there is no such thing as a universal lubricant possible.

It can be readily understood that the shaft of a flywheel weighing perhaps several tons, and running at a comparatively low speed, will require an altogether different kind of lubricant to the axles of an express train.

Machines running under a light load will require still another kind of lubricant, the chief point in this case being to employ one that will reduce friction to a minimum and consequently diminish the wear and tear, whilst ensuring easy running of the parts.

Very fine and small machinery, such as that of clocks and scientific instruments, needs lubricants that, in addition to minimising friction, will remain unaltered, or nearly so, during a long period of time, neither thickening, "gumming," nor corroding the metal, even in the course of years.

In works' machinery, vertical and marine engines, one lubricant will suffice, as a rule, for all seasons of the year, the machines being set up indoors and exposed to a fairly uniform temperature. The conditions are different with locomotive machinery, *e.g.* railway axles, which are exposed to the

greatest summer heat and winter cold. In climates where there is a wide difference between these extremes, a single lubricant will not be sufficient for this class of machinery, but the composition must be modified according to the time of year.

In the case of a lubricant, otherwise suitable, the degree of fluidity must be taken into consideration, the thinner it is the higher the rate of consumption as a rule. This is a factor deserving notice, especially in lubricants for the axles of vehicles.

For railway companies, the consumption of a minute quantity, more or less, of grease per axle a month is by no means an unimportant matter, the difference amounting to a considerable item of expenditure in view of the very large number of axles to be greased.

We have not yet arrived at the stage of being able to say with perfect confidence that such or such a lubricant is the best, most efficient, and most economical for a given purpose, some experts praising lubricants that are decried by others. The sole way to form a reliable judgment of the suitability, good and bad properties of lubricants, is by making prolonged and exhaustive tests with a number of these articles on a large scale.

With lubricants that are used in only small quantity for fine machinery, price is a secondary consideration, the chief point being to obtain preparations that satisfactorily fulfil the purposes of lubrication: diminution of friction, conjoined with perfect preservation of the machine parts.

PART II

SHOE POLISHES AND LEATHER SOFTENING PREPARATIONS

CHAPTER XXVI

The Manufacture of Shoe Polishes and Preparations for Varnishing and Softening Leather

THE preparation of these articles is a branch of chemical industry which is highly profitable, but is carried on in such a manner, in many instances, that the products, although of a fine deep black colour and giving a beautiful polish, alter the leather in a highly undesirable manner, making it brittle and liable to crack.

Most of the preparations used as shoe polishes consist of syrup, sulphuric acid, and bone black or lamp black, incorporated with a suitable proportion of low class fat, such as fish blubber, rancid lard, etc.

When bone black, *i.e.* powdered carbonised bones, is mixed with sulphuric acid, the calcium phosphate in the black combines with the acid to form potassium acid phosphate and calcium sulphate, the finely divided carbon in the black being set free and imparting to the polish its deep black colour.

The syrup also undergoes a change when brought into con-

tact with the acid, carbon being liberated. The addition of fat facilitates the application of the polish to the leather, and produces the polish when brushed for a short time.

Bone black may also be replaced by lamp black or vine black; and this modification is attended with certain advantages over recipes containing sulphuric acid. When this acid is used it is necessary to employ only just so much as will be fully neutralised by combination with the calcium phosphate of the bone black, since any excess of free acid will gradually destroy the leather to which the polish is applied. The leather will become covered with fine cracks, and will finally break in a number of places at once.

When one is not afraid of the trouble involved in intimately mixing with fat the finely divided carbon obtained in lamp black or Frankfort black, this mixture, when incorporated with the other ingredients, will form shoe polishes of unimpeachable colour, that not only do not corrode the leather but actually preserve it, owing to the presence of the fatty constituents.

Good bone black, ivory black (*Ebur ustum*), and Frankfort black fetch such high prices in commerce that it is far cheaper to prepare them oneself according to the methods about to be described, in which event they will cost only a fraction of their ordinary selling prices.

CHAPTER XXVII

The Preparation of Bone Black

THIS fine black pigment, also known as Paris black, is prepared by crushing bones (preferably those of calves or other young animals) into lumps the size of a nut, and placing these fragments in an old cast-iron retort or pot with a close-fitting lid. This vessel is then placed in a furnace in such a manner that it is surrounded on all sides by glowing coals.

Under the influence of the heat the organic substances in the bones soon begin to decompose, and gases are liberated that burn with a bright flame round the edges of the lid. Heating is continued so long as these gases continue to come off abundantly, but as soon as they cease, or the flame becomes dull and blue, instead of brilliant and white, the operation is complete, and the retort is taken out of the fire and allowed to cool with the lid on.

A still better method is to enclose the bones in an iron wire cage that fits the retort exactly. As soon as the carbonisation is terminated, the cage is taken out, its contents discharged into a tub of water, and the cage is filled with a fresh charge of bones and returned to the retort. By working in this way a considerable quantity of bones can be carbonised in a day in a small ironing stove.

The glowing bones, quenched by the water, should be light, porous, and of a pure black colour. If heavy, dense, and brown, they have been taken out of the furnace too soon; whilst if light, but greyish, especially in the upper layers, they are

over-burned, and air has gained access to the interior of the retort.

As already mentioned, access of air must be entirely prevented, otherwise the carbon in the bones will be consumed, and nothing will be left but the white porous bone ash. If the preparation of this latter product be desired, all that is needed is to place unbroken bones on a brightly burning fire, which may, in fact, be fed with them. They will then burn perfectly white, without, however, losing their shape; and when cold they will furnish perfectly white, porous masses, easily reducible to fine powder.

The quenched burned bones from the above carbonising process are allowed to dry superficially, and are then powdered in a mortar. It is not advisable to let them get perfectly dry first, as this makes the pulverising a troublesome operation, and a good deal of the powder is lost in the form of dust.

The resulting powder can be used direct, but when desired to be particularly fine it is levigated. To this end the finely powdered black is stirred up with water in the mortar and then poured out into a vessel full of water, where it is left to stand for half an hour, so that the coarser particles of black settle down to the bottom. The still black supernatant liquid is poured into another vessel, where it is left till all the black has subsided, leaving the liquid perfectly clear. This is carefully poured away, and the velvety powder at the bottom, which is extremely fine, is dried in the air. The coarser particles in the first vessel are ground over again.

The levigated black is a very handsome product, highly suitable for fine shoe polishes; but if desired for the preparation of fine leather varnishes, it can advantageously be put through a simple refining process, which purifies it still further at little expense, and converts it into so-called ivory black.

IVORY BLACK

Commercial ivory black is nothing more nor less than nearly pure carbon, obtained by suffusing moist, levigated bone black with crude hydrochloric acid, the quantity of acid generally used being equal to the original weight of bones calcined.

The hydrochloric acid dissolves, with considerable effervescence, the carbonates of lime and magnesia present in the black, and also the calcium phosphate comprising the bulk of the bone ash, leaving the carbon unaltered. The mass is stirred up repeatedly during the day, so as to ensure complete solution of the salts, and is then thinned down with sufficient water to enable the carbon to settle down, the sediment of carbon being repeatedly washed with water and finally dried.

The ivory black thus obtained forms an extremely fine powder, of a pure black colour, that is used for the finest lacquer varnishes, and can also be employed alone as an artist's colour.

THE PREPARATION OF FRANKFORT BLACK

Frankfort black is prepared in an entirely similar manner by carbonising vine twigs, the prunings being usually employed for this purpose. The operation of carbonising can be performed in old stove pipes, filled with the prunings and closed with a lid at each end. Heating is continued so long as inflammable gases are liberated from the mass.

The carbonised mass is quenched in water containing 10 per cent. of hydrochloric or sulphuric acid, and is left to stand overnight. The acid liquor dissolves out salts that are insoluble in water alone; and the residual carbon, when powdered and levigated, furnishes a very beautiful black.

CHAPTER XXVIII

Blacking and Shoe Polishes

THE preparations used for polishing boots and shoes may be subdivided into several classes, generally known respectively as blacking, boot varnish, and leather greases.

Blackings are mixed with water, applied to the leather, and brushed until a polish appears.

Boot varnishes are sold in a liquid form, and are applied to the leather with a brush, whereupon they dry with a bright gloss in a short time.

Leather greases are either semi-solid or oily masses, which are less intended to give a polish to leather than to make it soft and supple, and protect it against penetration by water.

GLYCERINE

Blacking is generally sold in the form of a mass with the consistency of butter, and is best kept in tins, since if packed in boxes or cardboard it dries up when stored for some time, cracks, and loses its fine black colour, so that the saving effected in the method of packing is counteracted by this drawback. An addition of glycerine, however, to the mass will impart the valuable property of remaining soft and glossy, even after prolonged storage.

Blacking containing glycerine can be made up into rolls and wrapped in wax paper. In fact, the addition of glycerine

confers such great advantages that it should never be omitted; it keeps the blacking soft for an indefinite period, facilitates its distribution in water, and prevents the usual tendency of blacking to turn mouldy.

At the same time it assists the blacking to preserve the leather, by making the latter very supple. Shoe leather that is constantly polished with glycerine blacking will never crack.

Pure glycerine is not necessary in the preparation of blacking, the crude brown glycerine, obtainable from candle-works at a low figure, being quite sufficient.

A large number of blackings present the defect of not polishing until they have been brushed for a long time. This can be remedied by rubbing a little fat on the leather before applying the blacking, or else by mixing a little oil (refined fish oil for choice) with the blacking itself.

With regard to the consistency of blacking, different users have different prejudices in this respect, some preferring a semi-fluid preparation, whilst others like it very solid. The consistency can be easily modified from one extreme to the other by suitably varying the proportions of fish oil and water.

Since it is more to the maker's advantage to sell blacking as thin as possible, the following recipes have been compiled with a view to giving this class of product. The finished product may, however, be thickened if desired, either by increasing the proportion of bone black or by evaporation. The former method is the cheaper, but the second gives very fine and uniform products.

The concentration of the blacking by the aid of heat is highly recommended when the preparation of very fine grades is in question. Flat, enamelled pans are used, and the mass is kept stirred, since otherwise it is liable to burn and assume a very disagreeable smell

VIENNA OIL BLACKING

Bone black	10
Syrup	10
Sulphuric acid	5
Fish oil	20
Water	4
Soda	2

This excellent blacking in all respects, is prepared in the following manner: The bone black, acid, and syrup are stirred up together in a porcelain or stoneware vessel, until the mass is uniform and shows a glossy black surface when left at rest.

The soda is dissolved in a little water, and is boiled with the fish oil in a pan, with constant stirring, until a thick mass is obtained, with which the first-named mixture is incorporated by stirring.

By increasing or reducing the proportion of the fatty mass to that of the black and syrup, the consistency of the blacking can be modified from thin and soft to hard and solid. The preparation sold as Paris blacking, and under other names, is compounded in the same manner as the foregoing.

In this, as in all other blackings prepared with sulphuric acid and bone black, the mass must be vigorously stirred as soon as the acid has been added, otherwise it will get lumpy, and the product will have an undesirable granular structure, whereas good blacking should always be soft, fine, and uniform when applied to the leather.

BLACK POLISH IN STICKS.

Tallow	40 parts
Yellow wax	10 ,,
Oil of turpentine	5 ,,

are melted together and stirred with a previously prepared mixture of 5 parts of fine black and 10 of olive oil. The fluid mass is cast into sticks, and these are rubbed against the leather, which is then polished with a woollen rag.

LYONS BLACKING

This French preparation is distinguished by its property of producing a beautiful black polish on leather without injuring the quality of the latter, whilst at the same time its prolonged use renders the leather nearly waterproof. On this account the article deserves close attention, especially since it can be produced cheaply. The following recipe will furnish an article of the highest quality:

1.	Soap	20
	Starch	10
	Gallnuts	10
	Green vitriol	10
	Water	2000
2.	Syrup	60
	Bone black	30

The substances grouped under 1. are boiled together for an hour, then strained through a linen cloth, and stirred carefully with the remaining ingredients whilst still warm.

HANOVERIAN BLACKING

1.	Bone black	18
	Syrup	9
	Sulphuric acid	4
2.	Gallnuts	4
	Water	10
	Green vitriol	2

The first mixture is prepared by stirring, in the cold, the second one by boiling the gallnuts in water for two hours, straining the decoction, and adding the green vitriol, the two mixtures being subsequently incorporated by stirring.

BERLIN BLACKING

1.	Bone black	100
	Syrup	50
	Sulphuric acid	10
2.	Tan bark	200
	Water	200
	Green vitriol	10

The first mixture is prepared by cold stirring; whilst the tan is boiled with the water for two hours, the green vitriol being dissolved in the decoction, and the whole stirred into the other mixture. Occasionally the following addition is made:

Logwood extract	50
Potassium bichromate	$\frac{1}{2}$
Water	50

this being prepared in the warm and greatly improving the gloss.

GLUE BLACKING

Glue is allowed to swell up in water, then melted and mixed with sufficient glycerine to form a highly elastic jelly when cold. With this is mixed enough lamp black to make the mass cover thoroughly when spread out thinly on paper. Since this blacking penetrates deeply into the leather, it is applied until no more seems to be taken up, and the leather is then polished with a woollen cloth.

WATERPROOF CAOUTCHOUC BLACKING

1.	Bone black	40
	Syrup	40
	Sulphuric acid	10
2.	Caoutchouc	4
	Linseed oil	10

The first mixture is prepared and allowed to stand for several days. Then the caoutchouc and linseed oil are heated together, filtered when cold, united with the first mixture, and the whole heated, with constant stirring, until it has become perfectly uniform. The product is of viscous consistency, and when applied continuously, renders the leather waterproof.

WAX SHOE POLISH

Yellow wax	50
Oil of turpentine	5
Potash	10

are melted together and treated with

Sugar	10
Water	500

The resulting white mass is stirred with enough lamp black to colour it deep black.

WAX POLISH

1.	Beeswax	10
	Soda	10
	Water	100
2.	Bone black	100
	Sulphuric acid	$2\frac{1}{2}$
	Syrup	100
	Fish oil	100

This polish, which is endowed with excellent properties, is prepared as follows: The wax is scraped thin and introduced by degrees into the liquor obtained by dissolving the soda in the water, the solution being then boiled until a scum no longer appears on the surface. Meanwhile the bone black, syrup, and acid are well stirred together, the fish oil being added when frothing begins to subside. The two mixtures are next incorporated, and the finished mass is packed in tins whilst still warm.

SPERMACETI POLISH

Beeswax	90
Spermaceti	30
Oil of turpentine	350

are melted together and

Asphalt lac	20
Lamp black	10
Prussian blue	10

are stirred into the liquid, the mass being scented, if desired, with 5 parts of nitrobenzol.

GUTTAPERCHA POLISH

1.	Guttapercha	20
	Olive oil	50
	Gum	20
	Water	1000
2.	Carbonised bones	200
	Lamp black	400
	Syrup	1500

The guttapercha is cut into small pieces, suffused with the olive oil, and heated with constant stirring, until a uniform

mass is produced, into which the gum, dissolved in the water, is then stirred. The second mixture is then prepared by stirring, and united with the still warm No. 1 mixture.

This polish is entirely free from acid, and therefore will never rot the leather. The presence of guttapercha renders the leather almost waterproof after repeated treatment with this blacking.

PATENT LEATHER STAINING PREPARATION

For some leather goods it is important to have a dull black colour that is not affected by water or other solvents, but remains permanent, a property desired more particularly in the case of belts and straps. Ordinary kinds of blacking, however, do not meet this requirement.

It is desirable not only to produce a permanent black stain on such leather goods, but also to treat boots and shoes in the same way, so as to lessen the consumption of blacking necessary to produce a shine, and also to keep the colour permanent, even though the gloss be spoiled, on prolonged exposure to wet.

A black stain may be produced on leather by boiling—

Logwood chips	1
Water	10

together for two hours, filtering the solution, and applying three or four coatings to the leather with a sponge or brush. Before this application, which stains the leather reddish brown, is dry, it is followed by one of a 1 per cent. solution of potassium bichromate, which changes the colour to a handsome blue-black. When the leather is dry, tallow or fish oil is well rubbed in, and blacking may then be used in the ordinary manner.

LIGNITE BLACKING

Powdered lignite, strained through bolting cloth, is suffused with strong caustic soda lye and boiled for several hours, at

the end of which time the liquor will have a very dark brown colour, whilst the powder has become very delicate and is nearly as handsome in colour as ivory black. The whole liquid is turned out into a vessel containing several hundred times as much water, and is there left to settle, the black powder being collected on a paper filter, dried, and stirred up in suitable proportion with—

Fish oil	10
Lard	50

BELGIAN BLACKING

Potatoes	10
Sulphuric acid	1
Bone black	5
Lard	20
Fish oil	40

The potatoes are pulped, suffused with the sulphuric acid and heated, with constant stirring, in a stoneware or porcelain vessel, until the mass has turned dark brown. The bone black is next added, followed by the fat and fish oil in the warm. Vigorous stirring is important. Should the mass prove too stiff, it is suitably thinned down by gradual additions of fish oil. Care, however, is needed here to prevent the mass keeping too thin and becoming greasy, in which event a little bone black must be added.

INDIGO BLACKING

The article generally sold as indigo blacking has no indigo in it at all; and, indeed, the author has found that indigo is of no particular use in blacking. When used, the indigo must be very finely powdered and ground with fat or oil, or else employed in the soluble form of indigo-carmine. In either case,

the resulting product can only be compared, with disadvantage, to ordinary well-made blacking. It is never a pure and glossy black, but always an indefinite black that polishes with difficulty when brushed.

Moreover, the high price of indigo would preclude its use for such a cheap article as shoe polish. A preparation, with a fine bluish tinge, and at the same time cheaply made, is obtained from—

Syrup	6
Sulphuric acid	4
Bone ash	6
Prussian blue	2
Lamp black	4
Fish oil	12
Lard	8

The sulphuric acid is first mixed with the bone ash, then with the syrup and lamp black, and finally the other ingredients are incorporated.

GLYCERINE BLACKING

Good blacking should remain soft like butter, even when kept for several years, and should be easily got out of the package and mixed with water. Many otherwise good blackings, however, are subject to dry and crack when they have been packed in wooden or cardboard boxes. Sometimes they set quite hard, and are then difficult to soften with water.

This defect can nevertheless be cured by mixing the finished blacking with a little glycerine (3–4 per cent. will be quite enough) before it is packed for sale.

Glycerine is a substance of oily character, and is very hygroscopic, so that it keeps the blacking constantly moist. It also possesses the valuable property—already alluded to—of making

the leather soft and supple, besides keeping it from getting mouldy. On this account it forms a useful adjunct to leather-softening preparations, as it is miscible with both fat and water in any proportion.

LIQUID BLACKING

1.	Bone black	120
	Olive oil	30
	Syrup	60
	Sulphuric acid	30

These bodies are mixed, the black being first rubbed down in the oil, the syrup stirred in next, and the acid last.

2.	Gum arabic	30
	Grape sugar	30
	Water	500

The gum and sugar are dissolved in the warmed water, and the solution is gradually mixed with the first mixture. The finished article is filled into bottles.

LOWY'S BLACKING

Powdered gallnuts	1,000
Logwood extract	40
Vinegar	25,000

These substances are boiled for half an hour, and strained, the liquid portion being treated with 300 parts of green vitriol and left for twenty-four hours. The clear portion is then drawn off and warmed with—

Gum	250
Sugar	3000
Syrup	2000

until these substances are dissolved. The liquid is treated with—

Spirit of wine	2000
Shellac solution	1000
Tannin	130

This blacking is liquid, and must be stored in bottles. The shellac solution is prepared by dissolving as much shellac in very strong spirit as the latter will take up.

In the original recipe an addition of 1200 parts of powdered indigo is recommended; but this ingredient is now omitted, since it does not contribute to the quality of the product and makes it much dearer.

IRON BLACKING

Bone black	12
Syrup	50
Sugar	8
Fish oil	6
Sulphuric acid	2

These are stirred together until a uniform mixture is obtained, the following being then added:

Tan decoction	8
Green vitriol solution	6
Bone black	30
Sulphuric acid	4
Paris blue	4

FERROCYANIDE BLACKING

1.	Potassium ferrocyanide	32
	Water	9000
2.	Green vitriol	100
	Water	1000
	Nitric acid	15

Solution No. 2 is poured into No. 1 so long as a precipitate forms. Of the wet precipitate, 2000 parts are taken and mixed with—

Bone black	4000
Fish oil	1000
Syrup	2000
Water	2000
Sulphuric acid	500

When ultimately mixed, the mass is packed in boxes.

CHAPTER XXIX

Leather Varnishes

LEATHER varnishes are merely ordinary varnishes, well prepared and stained black. Good leather varnish should dry rapidly, and be specially characterised by elasticity. It should not crack or break, even when the leather is bent strongly and sharply; and it should either be glossy at once, or take a fine gloss when rubbed with a flannel or other soft cloth.

The leather varnishes may be divided into two classes, according to the method of preparation: spirit varnishes and oil varnishes. The former contain various substances dissolved in alcohol, and as they dry hard very quickly on being applied, they must be kept in tightly closed bottles.

The oil varnishes prepared with linseed or other oil, usually take twelve to twenty-four hours to dry, and then furnish coatings distinguished by fine gloss, durability, and great elasticity.

When it is desired to apply several coatings of leather varnish in succession, each coating must be allowed to get perfectly dry before applying the next: otherwise uneven coating will result.

GLOSSY VARNISHES

(Glossy Black Leather Varnish)

Boiled oil	200
Powdered umber	40
Asphaltum	80
Oil of turpentine	200

The boiled (linseed) oil is heated somewhat strongly in an iron pan, along with the umber and asphaltum, and stirred until all is dissolved, the turpentine being then stirred in. The varnish should be fairly viscous. On leather it forms, in a few hours, a fine glossy coating of great durability.

ANTACID BOOT-LEATHER VARNISH

As the name implies, this preparation is free from acid. It forms a kind of stain, containing the necessary adhesive substances to enable it to stick properly to the leather. It is prepared as follows:

Powdered gallnuts	50
Logwood	30
Water	200

These are boiled for two hours, filtered, and

Syrup	200
Green vitriol	30

are dissolved in the liquid, which is next boiled until it begins to thicken, whereupon a solution of

Ruby shellac	1
Alcohol	20

is added and well stirred in, the liquid product being then filled into bottles.

BLACK LEATHER VARNISH

Caoutchouc	100
Petroleum	100
Carbon disulphide	100
Shellac	400
Bone black	200
Alcohol	2000

The caoutchouc and carbon disulphide are placed in a well-stoppered flask and left to stand for several days. As soon as

the caoutchouc has swollen up, the petroleum is added, with the spirit, followed by the finely powdered shellac, the whole being warmed to about 122° F. As soon as the liquid seems fairly clear, indicating that all the substances are dissolved, the bone black is added, with vigorous shaking, and the varnish is immediately filled into bottles, which are tightly closed.

This varnish dries rapidly, and forms a smooth, fairly elastic, deep black coating on leather.

HARNESS VARNISH

Brown shellac	370
Venice turpentine	190
Alcohol	1600
Lavender oil	60
Lamp black	30

BLACK HARNESS VARNISH

Shellac	24
Sandarach	4
Elemi	4
Venice turpentine	16
Oil of turpentine	12
Alcohol	100
Lamp black	40

The resins and turpentine are mixed with the oil of turpentine and heated to boiling, the alcohol being stirred into the cooled mass, and followed by the lamp black.

BLACK VARNISH FOR BELTS

Shellac	100
Pine resin	20
Venice turpentine	50
Oil of turpentine	40
Alcohol	1000
Lamp black	40

When applied to belts, this varnish, which is fairly elastic, soon forms a fine uniform coating, which dries rapidly, and does not easily crack, even when the leather is strongly bent. For this reason it is very useful for boot leather.

ELASTIC LEATHER VARNISH

(*Flexible Blue Varnish*)

This varnish, which has a beautiful blue gloss, is extremely flexible and very durable, is prepared in the following manner:

Prussian blue is boiled with linseed oil, the blue being powdered, dried, and introduced into an iron pan containing the heated oil. The proportions are:

Linseed oil	1000
Boiled linseed oil	100
Prussian blue	200

When the blue has been stirred in, the mass is quickly heated to such a high temperature that the linseed oil begins to give off fumes, and sometimes takes fire. In view of the latter contingency, which is undesirable, a sheet-iron cover is held in readiness to place on the pan and extinguish the flame.

This operation of boiling the Prussian blue and oil together is accompanied by certain chemical reactions, which have not yet been closely investigated; the linseed oil turns dark brown to black, and thickens. To prevent the blue from settling down, the liquid is repeatedly stirred.

After boiling for several hours—three to four being generally sufficient—the mass is left to stand at about the boiling temperature of water. The undissolved portion of the Prussian blue sinks to the bottom, leaving the liquid clear, but so dark

in colour that it appears black, even in thin layers. It is poured into bottles immediately.

To obtain successful results in this process, the following points should be observed:

Only the finest grades of Prussian blue should be used, the commercial name for this quality being Paris blue. The value of a sample of this blue may be estimated by its great weight, and by the peculiar metallic lustre on the surface of fracture when a lump is broken across.

The lighter coloured "Berlin blue," which lacks the metallic lustre, often contains only 30 per cent., or even less, of the active substance. It is highly important that the blue should be thoroughly dry, since only when this is the case is the product successful.

The varnish should always be boiled in a pot containing the residual blue from a previous operation, since this enables the residue to be utilised.

To apply this excellent varnish to leather (the latter must not have been previously blacked or polished), a suitable quantity of the varnish is warmed in a pan until fairly thin, and then laid on the leather hot. The resulting coating is a deep blue-black, dries overnight, and will stand the action of the weather perfectly. The leather can be bent to any extent without injury.

CAOUTCHOUC VARNISH

(*Ordinary Caoutchouc Varnish*)

Caoutchouc	10
Petroleum	20
Oil of turpentine	10
Boiled linseed oil	500

The caoutchouc is first dissolved by warming with the petroleum and oil of turpentine, the boiled oil being added

next. If the varnish is to be black, 50 parts of fine lamp black are stirred in.

ELASTIC CAOUTCHOUC VARNISH

Refined pine resin	10
Oil of turpentine	5
Caoutchouc	5
Linseed oil	10

The pine resin and oil of turpentine are melted together, the caoutchouc and linseed oil being then added, and the whole stirred until a uniform mixture is produced. When applied to leather this varnish will long remain elastic, even in the cold, without cracking.

CAOUTCHOUC VARNISH FOR RUBBER SHOES

Caoutchouc	70
Refined pine resin	140
Oil of turpentine	250
Bone black	20

The caoutchouc and oil of turpentine are heated together somewhat strongly, the resin being then melted in the solution and the bone black stirred into the hot mass.

CAOUTCHOUC REPAIRING VARNISH

Caoutchouc	10
Benzol	70

The caoutchouc and benzol are placed in a carefully closed flask, which is exposed to sunlight until solution is complete. This varnish is highly suitable for repairing worn rubber shoes and waterproof coats. The damaged parts are painted over with the varnish, and the edges of cracks are pressed together and held for a few minutes in that position.

ASPHALTUM VARNISH

Syrian asphaltum (bitumen) is a substance very insusceptible to the action of chemicals, and is distinguished by a handsome black colour, both of which properties render it extremely suitable for use in varnishes for leather, wood, metals, etc. A varnish suitable for all purposes can be obtained by shaking up the finest Syrian asphaltum in a flask with rectified oil of turpentine, the two being left in contact until complete solution can be assumed to have occurred. The flask is left to stand for a week longer, to enable any undissolved matter to settle down, the supernatant liquid being afterwards poured off from the sediment. If necessary, the solution can be thinned down with oil of turpentine: the thinner the coating on the leather, the higher the gloss.

LIQUID ASPHALTUM GLOSSY VARNISH

Syrian asphaltum	10
Oil of turpentine	10
Petroleum	10

are placed in a closed flask and left to stand for several days, with repeated shaking. Meanwhile

Lamp black	1
Linseed oil	5

are rubbed down together, and then incorporated with the asphaltum solution by stirring. The finished varnish must be filled into tightly closed bottles.

CHAPTER XXX

Leather Softening Preparations

THESE preparations are used for the purpose of preserving the leather, making it soft and flexible, and preventing the penetration of water. Such of them as are fluid and of an oily nature, are simply rubbed into the leather with the hand or a woollen cloth, whilst the more solid ones must first be liquefied by heat.

In all circumstances it is advisable to use these preparations, whether liquid or solid, in the warm, since in this condition they penetrate much farther into the leather than when used at the ordinary temperature.

The first time of using, it is advisable to leave the leather to stand in a warm place, until the gloss produced by the preparation has disappeared, *i.e.* till the preparation has been fully taken up by the leather.

It is a widespread error that wet leather cannot be greased, but ought first to be thoroughly dried. This is incorrect, and, besides, the leather gets hard and brittle in drying, and then takes a long time to resoften by the aid of greases.

Wet leather, on the other hand, is in a very suitable condition for greasing, all that is necessary being to wipe it over with a dry cloth until the grease will stick, and then to rub the latter well in. Drying can be conducted at the ordinary temperature, or with the aid of heat, without the leather getting hard or brittle; so that under these conditions it fully retains its flexibility and softness.

SOAP GREASE FOR BOOT UPPERS

One hundred parts of soap are dissolved in 1000 of water, and 100 parts of glycerine, 25 of beef tallow, 25 of fish oil, and finally 25 parts of colophony are added. The whole is boiled for some time, and then stirred until cold.

HARNESS GREASE

Soap	2
Sugar	2
Water	4
Potash	1
Rape oil	20

The solids are dissolved in the water, and stirred with the rape oil, in the warm, until a uniform mixture is obtained.

GLOSSY WATERPROOF GREASE

Wax	1
Soap	1
Lamp black	3
Oil of turpentine	5
Fish oil	20

The wax is dissolved in the oil of turpentine by the aid of warmth, the soap is scraped and added, followed by the fish oil (still in the warm), and finally by the lamp black.

WATERPROOF LEATHER GREASE

Oleic acid	24
Crude stearic acid	6
Ammonia soap	18
Tannin extract	3
Water	24

The oleic acid and crude stearic acid are melted together, the ammonia soap being then added by degrees, followed by the tannin extract, and finally by the water.

The ammonia soap is produced by adding ammonia to hot oleic acid, until the smell of ammonia no longer disappears after prolonged stirring, and the whole has set to a jelly.

By adding to this grease a solution of 2 parts of green vitriol in 6 of water, it is stained a deep black, and is then admirably adapted for application to shoe leather.

WATERPROOF LEATHER GREASE

Wax	30
Asphaltum	10
Oil of turpentine	50
Linseed oil	100
Olive oil	100

The wax and asphaltum are dissolved in the warmed oil of turpentine; and the olive oil and linseed oil, having been heated together, are poured into the solution, the whole being made homogeneous by stirring.

GLOSS FOR GREASED LEATHER

1.	Ruby shellac	200
	Alcohol (95 per cent.)	1000

The shellac is dissolved, in the course of a few days, by repeatedly shaking it up in the spirit, in a bottle that is stored in a warm place.

2.	Marseilles soap	25
	Alcohol (95 per cent.)	400
	Glycerine	40

The two solutions are mixed together and united with a solution of 5 parts of nigrosine in 120 of spirit. This addition gives the gloss a beautiful black colour.

FISH OIL LEATHER GREASE

Fish oil—of itself an excellent softener for leather—is, in many cases, precluded from use by its highly disagreeable smell. To remove this defect and enable the oil to penetrate readily into the leather, the oil is stirred up with a solution of tannin, until the smell has disappeared and the entire mass has assumed the consistency of butter.

It is then left to stand, the fat is separated from the watery portion, and is then treated with a very small quantity of carbolic acid, which preserves the refined oil from going rancid in storage. The proportions used are:

Fish oil	100
Tannin	2
Water	10
Carbolic acid	50

GREASE FOR WADING BOOTS

Spermaceti	20
Wax	40
Pine resin	30
Turpentine	50
Linseed oil	400
Fish oil	200

The wax, spermaceti, and pine resin are melted together, the turpentine being then added, followed by the linseed oil and fish oil, the whole being heated to the boiling point of water and stirred for half an hour.

RESIN GREASE FOR LEATHER

Pine resin	10
Oil of turpentine	3
Lard	30

The resin is dissolved in the oil of turpentine by the aid of heat, the lard being then added, and the whole mixed to a uniform mass by continued stirring, after which it is left to cool. When endeavours are made to expel the oil of turpentine by protracted heating, this can only be done without injury to the product, provided the temperature employed does not exceed about 356° F., at which temperature the oil of turpentine will vaporise very quickly without the fat being affected. Any higher temperature, however, partly decomposes the fat, and forms products that would injure the leather.

For leather subjected to frequent bending, this grease is unsuitable, but it is very useful for harness, belts, etc.

CAOUTCHOUC GREASE

Caoutchouc	8
Oil of turpentine	8
Lard	10
Fish oil	50
Tallow	10
Lamp black	2

The caoutchouc is dissolved in the warmed oil of turpentine, and the filtered solution is poured into the melted fat, which has previously been stirred up with the lamp black.

PATENT CAOUTCHOUC GREASE

Caoutchouc	1
Oil of turpentine	5
Brown sugar	40
Sulphuric acid	5
Rape oil	40
Bone black	8

The caoutchouc is dissolved in the oil of turpentine, the sugar and bone black are treated with the sulphuric acid in the

warm for several hours; the two mixtures are united, mixed with the rape oil and heated for an hour.

VASELINE AS A GREASE AND PRESERVATIVE

Vaseline is an exceedingly valuable emollient for any kind of leather, since the very hardest leather can be softened by repeatedly rubbing in vaseline till it will not take up any more. At the same time the leather is enabled to offer greater resistance to the penetration of moisture, and is preserved from becoming brittle.

Another point in connection with which the value of vaseline has received too little attention, is for protecting metals from rusting or tarnishing in the air. The best way to apply the vaseline is to rub it well over the whole surface of the object (*e.g.* guns, swords, etc.) with the hand, and then polish over with a soft woollen rag, using a considerable amount of pressure, till the surface seems quite clear again. Despite the rubbing, however, a very thin layer of the vaseline remains on the surface of the metal, sufficient to preserve it for a long time from rusting.

VASELINE GREASE FOR LEATHER

Vaseline can be used on natural leather by itself, but for black leather the following composition is recommended:

Vaseline	100
Lamp black	5
Prussian blue	5

A small portion of the vaseline is melted in an enamelled iron pan, the lamp black and Prussian blue being added, and stirred until the mass is uniform. The rest of the vaseline being afterwards stirred in by degrees.

CHAPTER XXXI

The Manufacture of Dégras

THE product known as dégras, or tanner's grease, is distinguished by its property of penetrating leather with great ease, and imparting extreme softness and suppleness to the same. Hence, when it is desired to make hard leather soft and flexible, dégras forms the best means for effecting the purpose in view.

Before the properties of the fats had been more closely investigated, dégras was prepared in a very peculiar manner, owing to which circumstance it was only obtainable in small quantities commercially, and was high in price. Even now that it can be produced in any quantity, the price is still comparatively high, so that the process is a very profitable one.

Dégras is only fat in a state of emulsion, *i.e.* fat distributed very finely in a liquid of suitable character, so as to form a mass of the consistency of ointment or butter.

The characteristic feature of good dégras is that it is very readily absorbed by leather to which it is applied, and such leather no longer heats when piled up in heaps, but in a short time appears to be uniformly impregnated with the mass.

PRODUCTION OF DÉGRAS AS A BY-PRODUCT IN MAKING SHAMOY LEATHER

In the manufacture of shamoy leather the suitably prepared skins are sprayed with fish oil and thrown into heaps. Owing to the incipient decomposition of the fat the heaps soon grow

rather hot; and after a certain time the skins are put through a fulling process, and finally treated with a 10 per cent. solution of potash. There then forms a white liquid, in which the fat is found to be distributed in the form of exceedingly fine drops.

This liquid is treated with sufficient sulphuric acid to neutralise the potash, whereupon the fat collects on the surface, as a dirty white or yellow to brown mass, of rather mild flavour, and specially adapted for softening tanned leather, which absorbs it greedily.

In many works, skins are shamoyed for the special purpose of producing dégras, inasmuch as, after being fulled and treated with potash, the skins are resoaked with fish oil, left to heat, fulled, and treated again with potash, this cycle of operations being repeated until the skins drop to pieces.

PRODUCTION OF DÉGRAS FROM FISH OIL

A much simpler method of producing dégras, however, is by emulsifying fish oil in the following manner: A solution of potash (10–20 per cent. strength) is boiled in a roomy pan, and fish oil is run into the hot liquor, as a very thin stream, from a tank overhead, the water being kept stirred by means of paddles, etc. The quantity of fish oil used must be determined in each case. Of some kinds as much as 50 per cent. of the mass in the pan may be taken, but in others, again, a much smaller proportion must be used.

After all the fish oil is in, the stirring is continued for a considerable time, and the mass is heated further, samples being drawn at intervals. When one of these samples no longer separates into two layers on being left to stand for some time in a high test-glass, but forms a homogeneous milky liquid, the operation is complete. The finished dégras is then stirred whilst cooling, until it begins to grow viscous, whereupon it is poured into the sale packages.

In the majority of cases the above procedure will give very favourable results, and a product fulfilling all requirements. With some kinds of fish oil, however, all attempts to produce a good dégras are in vain. The heating and stirring may, for example, be continued for hours, and the resulting mass will give up a large proportion of its fat on standing. Hence one is forced to conclude that certain kinds of fish oil are incapable of forming an emulsion with potash solution. It is therefore always advisable to test the suitability of the fish oil by treating a small quantity with potash solution in an enamelled pan, with constant stirring.

Fish oil that will not thoroughly emulsify with potash solution may be made to do so by first heating some weak caustic soda in the pan, and stirring the oil with this until it grows milky, which done, a very strong solution of potash can be added, and stirring continued so long as a drop of fat can be detected in the liquid, whereupon the already mentioned test is applied.

The *modus operandi* is as follows: A 1 per cent. solution of caustic soda is prepared by dissolving drum soda in the pan; and the fish oil and potash solution are stored in two overhead tanks fitted with taps. The potash solution, it may be stated, is prepared by mixing potash and water in equal amounts, and stirring them, at frequent intervals, during twenty-four hours, at the end of which time the solution is poured off from any undissolved residue and transferred to the tank aforesaid.

The soda lye having been heated to boiling, the oil tank tap is turned on far enough to allow a stream of oil, about the thickness of a pencil, to run into the pan, the contents of which are kept well stirred all the while. When all the oil is in and the liquid has become milky, the potash solution is also run in as a thin stream, and the whole stirred until a satisfactory sample is obtained.

To obtain a product of greater consistency, a somewhat larger proportion of caustic soda must be taken, the solution being made $1\frac{1}{2}$–2 per cent. strength in place of 1 per cent. The exact amount, however, must be ascertained by a preliminary experiment, since an excess would give a product more like soap than ointment. The dégras should be of such consistency that it can be easily applied to leather with the finger and be rapidly absorbed by the material.

OLEIN DÉGRAS

Olein or oleic acid, the by-product from stearine candle works, can be very advantageously employed in the preparation of a very useful dégras, though one inferior to that obtained from fish oil. The method of preparation is the same as for fish oil dégras, the olein being run into the boiling caustic soda lye; but the milky stage is generally reached more quickly.

If the quickly cooled sample shows the finished product to be too fluid, a corresponding quantity of olein soap is added to the hot mass in the pan. To enable this soap to dissolve rapidly and without remainder, it must be cut into fine shreds and stirred until not the slightest white fragment of undissolved soap can be seen in the samples, the latter being quite homogeneous.

Some practical men look upon brown dégras as being stronger than that of lighter colour—an opinion that is devoid of foundation, the colour being derived solely from the use of some dark fish oil in the manufacturing process.

However, the desire of consumers to have a dark-coloured dégras can be easily gratified by suitably colouring the contents of the pan whilst still hot. The best means for this purpose is a very strong decoction of tan or tannin extract. This solution is poured into the dégras as a thin stream, and stirred until the whole mass has acquired an even colour. In this case also it is desirable for the buttery consistency to be retained.

When a good sample of dégras is spread thickly on a sheet of glass and held up to the light, it should have a uniformly translucent appearance, without exhibiting lighter or darker patches.

BLACK DÉGRAS

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THE END

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